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COLD LAKE - BEAVER RIVER WATER MANAGEMENT STUDY

VOLUME 7

ECOLOGICAL INVENTORY OF LAKE SHORELINES

Appendix K . . . . Ecological Inventory of Lake Shorelines; Summary
Appendix L . . . Ecological Inventory of Lake Shorelines; Detailed Report

Water Resources

Alberta

ENVIRONMENT
Planning Division

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COLD LAKE — BEAVER RIVER
WATER MANAGEMENT STUDY

VOLUME 7
ECOLOGICAL INVENTORY OF LAKE SHORELINES

PREPARED BY
PLANNING DIVISION
ALBERTA ENVIRONMENT
December 1983

Submitted to: Hon. F. Bradley
Minister of Environment

APPENDIX K

ECOLOGICAL INVENTORY OF LAKE SHORELINES; SUMMARY

A Report Prepared By
C.A. MCGREGOR
RESOURCE APPRAISAL SECTION
RESOURCE EVALUATION AND PLANNING DIVISION
ALBERTA ENERGY AND NATURAL RESOURCES

Alberta
ENERGY AND
NATURAL RESOURCES

MEMORANDUM

FROM J.R. Harrower, Director
Resource Evaluation Branch

OUR FILE REFERENCE

YOUR FILE REFERENCE

TO R. Hicks
Athabasca Basin Planner
Planning Division
Alberta Environment

DATE May 30, 1983

TELEPHONE 427 - 3505

SUBJECT ECOLOGICAL INVENTORY OF SHORELINES OF SELECTED LAKES IN THE COLD LAKE REGION, VOLUME I and II

I am pleased to present you with our final report entitled "An Ecological Inventory of Shorelines of Selected Lakes in the Cold Lake Region, Volume I and II".

The report contains an inventory of the shorelines of 13 lakes for inclusion in your water management plan.

If you have any questions regarding the report, please contact either myself or Cameron McGregor, the study author.

Thank you for the opportunity to contribute.

J Harrower
J.R. Harrower

Attached

c.c. J.R. Prokopchuk
C.A. McGregor

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EXECUTIVE SUMMARY

Thirteen lakes in the Cold Lake region were inventoried in terms of their surficial materials, vegetation, erosion potential and their susceptibility to artificial water level fluctuation.

The study was undertaken as part of an investigation and selection of suitable lakes for water storage for use by municipalities and industry in the region, under the direction of the Water Management Branch of Alberta Environment.

The study applies a nationally used land classification system (Ecological Land Classification) to the land-water interface for the first time in Alberta. Because of the ecological nature of the classification (concentrating on the relationship between plants and their growing medium) the method is inherently predictive.

The study was conducted for three primary users:

1. Those who wish to compare lakes to select those most appropriate for use (Volume I) ;
2. Those who wish to restrict their consideration to one lake to predict the effect of water level fluctuation on shoreline types (Volume II, Appendix II-III);
3. Those who wish to work in detail on one shoreline type to predict the effect of water level fluctuation on

specific plant species (Volume II, Appendix IV).

The study is confined in scope to only those elements which affect primary productivity (plant growth). Secondary productivity (effects on fish, wildlife, recreation, etc.) are considered elsewhere.

The basic findings of the study are:

1. Lakes sensitive to any water level fluctuation (beyond their natural fluctuation) include: Moose, Long Bay, Caribou, Tucker, and Reita;
2. Lakes sensitive to water withdrawal below their natural levels include: Wolf, Marie, Ethel, Burnt, May, Manatokan;
3. Lakes sensitive to flooding above their natural levels include: Muriel and Angling.

PREFACE

This study was requested by Alberta Environment as part of its investigation of the potential for water storage in selected lakes in the Cold Lake area. The water storage is required to allow withdrawals for municipalities and industry and to augment surface flow for fisheries, wildlife, recreation, and water quality.

By artificially varying the natural lake levels, Alberta Environment might inadvertently affect other lake users. This study and others within the program were undertaken to predict these effects.

The project was initiated during talks between myself and members of the Alberta Environment Planning Branch. We felt it was a good opportunity for interdepartmental cooperation and for the introduction of "ecological" tools of Energy and Natural Resources to Alberta Environment.

Initial discussions occurred during May-June, 1981 with proposal submission occurring during June-July. Fieldwork was completed during August. Preliminary drafts were submitted to the Alberta Environment project team from December through March. Though, this time, a contract for a literature review on the effect of water level fluctuation on vegetation (Appendix III) was developed, let out and completed. Final report preparation occurred during July, August, and December, 1982.

ACKNOWLEDGEMENTS

Ron Hicks, Athabasca Basin Planner, provided the project management and logistical support for this project. Many thanks are due him for its completion.

Neil Van Waas, now Resource Coordinator, Rocky Mountain House, was the primary support for the development of this project from Energy and Natural Resources. His contributions, though brief, were especially appreciated.

Ian Stirling from Alberta Environment provided field assistance along with my wife Janice.

Gary Hryhorak, Betty Hope, Dale Polutranko, and Sandy Gillespie provided drafting and collation. Cheryl Garbutt, our secretary, was responsible for final report preparation.

Brian Kemper and Bruce MacLock provided initial contacts for the project and guided it from afar.

Rick Haag and Brian Husband compiled a detailed literature review of the moisture relations of dominant plants in the area.

Finally, many thanks are due my wife Janice who originally conceived of the study and was involved in every aspect of its completion.

1.0 INTRODUCTION

Environmental impact assessment has had quite a checkered history in the last fifteen years since it entered the planning function in both the public and private sectors. Many different approaches have been attempted including many expensive failures which were of use only to the scientists who developed the approaches. Nonetheless, it is necessary in most major developments to consider carefully the environments they affect if only to make certain the benefits which may accrue from development are not less than the costs over the short and medium term.

Ecological Land Survey has been adopted in the Federal Environmental Assessment and Review Process (EARP) for major developments on Federal Crown land (Lands Directorate, no date). It is also presently used within the planning process of Alberta Energy and Natural Resources. The method has not been well developed for the land-water interface (Welch 1978) which is of important concern to a water management agency such as Alberta Environment. This project has been designed to overcome the land bias of the method and has provided useful data to the Alberta Environment team for impact prediction.

1.1 The Process and Participants

Central to Alberta Environment's study were the water resources of the area and their potential for use by municipalities and industry.

Thirteen lakes were selected for investigation as they were thought to supply adequate throughflow (Ron Hicks, pers. comm.). Each lake and the drainage basin it occupied were modelled using a water balance approach (Nanuk Engineering Development Ltd. 1981).

The input to the water balance model included data on lake levels, both above and below the mean, which were:

(a) acceptable - little environmental degradation

(b) some environmental degradation

(c) extreme environmental degradation

This study and the others associated with it were to develop those lake levels corresponding with each class. A brief schematic of interaction is included in Figure 1.1.

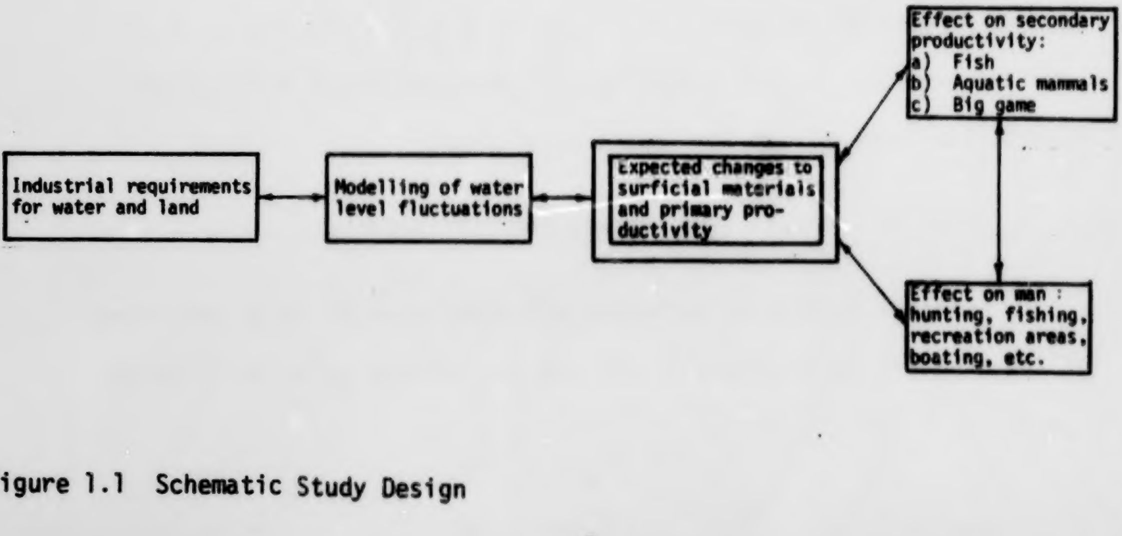

Industrial requirements for water and land
Modelling of water level fluctuations
Expected changes to surficial materials and primary productivity
Effect on secondary productivity:
a) Fish
b) Aquatic mammals
c) Big game
Effect on man : hunting, fishing, recreation areas, boating, etc.

Figure 1.1 Schematic Study Design

1.2 The Area

The study area is located approximately 300 km east of Edmonton on Highway 16 (Figure 1.2.1). Most of the lakes have road access to their shores except for May, Burnt, Caribou, and Reita. Caribou and Burnt Lakes occur on the Air Weapons Range.

The major physiographic units of the area and their pertinent features are delineated in Figure 1.2.2. The figure and physiographic summary were adapted from Kocaoglu (1975).

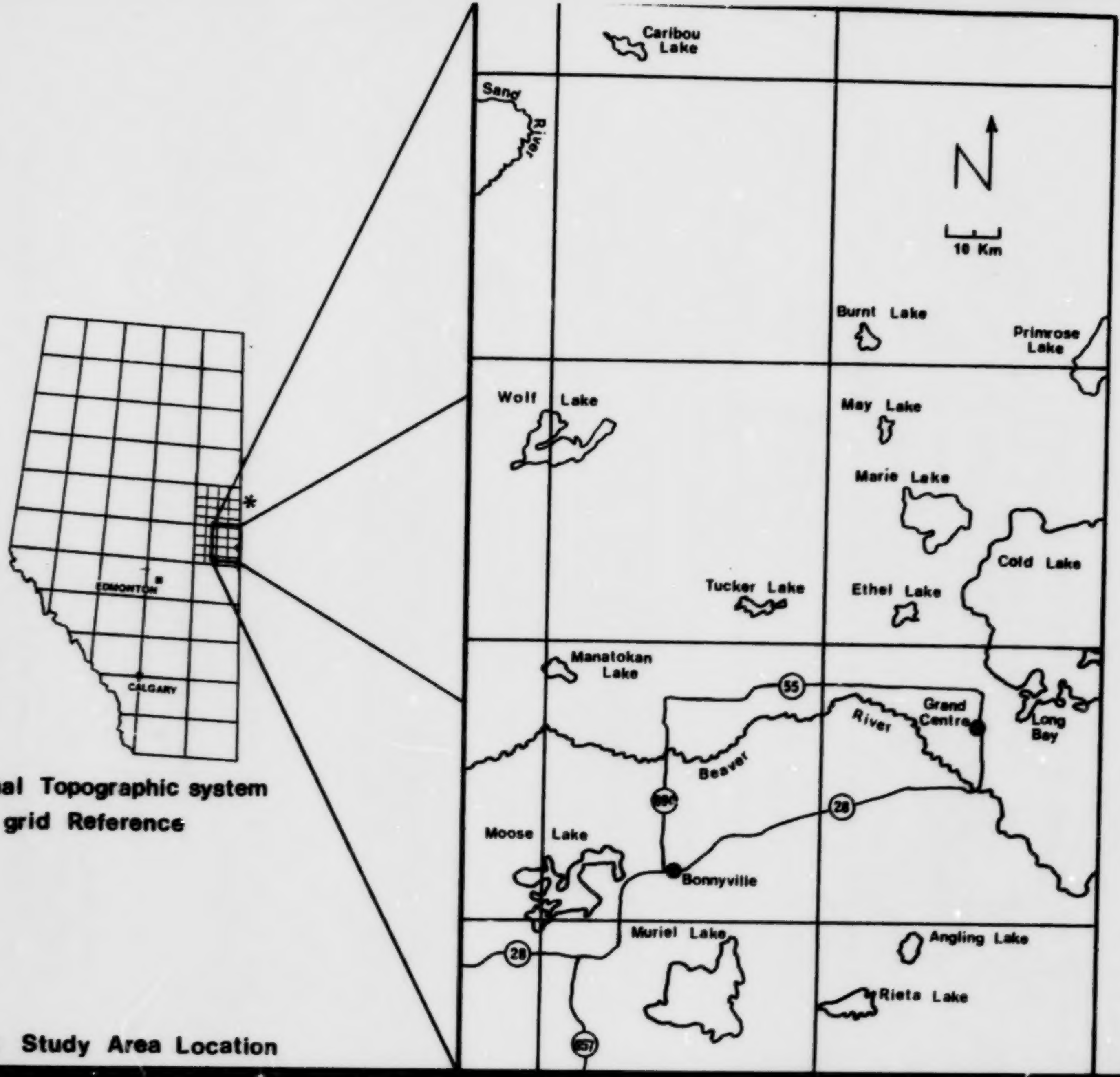
1.2.1 Vegetation-Soils

The study area occurs in the Boreal Mixedwood Ecoregion (Strong and Leggat, 1981) and is predominantly forested by aspen and white spruce. In the southern third of the study area cultivation and forage production have removed this native flora. Many of the lakes of this study area are presently unaffected by the agricultural activity; however, some are plowed or grazed to the shoreline.

1.3 Primary Productivity - An Ecological Approach

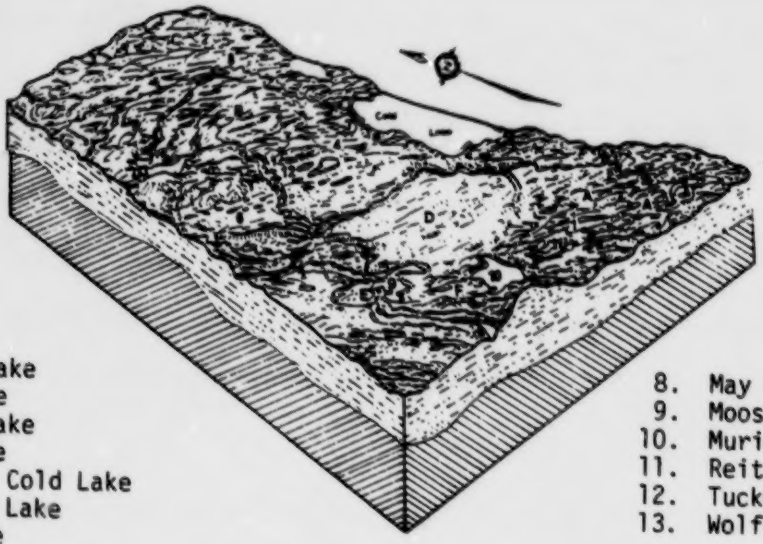
A more detailed discussion of the method for this study is outlined in Appendix V which includes the major proposals and terms of reference.

Briefly, on and off-shores of thirteen lakes (to 3 m above and below the present water level) in the Cold Lake area were inventoried



* National Topographic system grid Reference

Fig. 1.2.1 Study Area Location



1. Angling Lake
2. Burnt Lake
3. Caribou Lake
4. Ethel Lake
5. Long Bay, Cold Lake
6. Manatokan Lake
7. Marie Lake
8. May Lake
9. Moose Lake
10. Muriel Lake
11. Reita Lake
12. Tucker Lake
13. Wolf Lake

Physiographic Unit	Topography	Drainage	Dominant Vegetation	Lake Types
Hummocky Morainal Plain; clayey	Moderately rolling	Well drained, many small wetlands	Closed Mixedwood Forest	Shallow bays, shallow lakes
Rolling Morainal Plain; clayey	Undulating to moderately rolling	Moderately well drained to poorly, many moderate to large wetlands	Closed Mixedwood Forest	Deep large lakes
Rolling Morainal Plain; clayey to sandy	Gently undulating to gently rolling	Well drained to poorly drained; many moderate large wetlands	Closed Mixedwood and Coniferous Forest	Many moderate depth and sized lakes
Undulating Morainal	Undulating	Well drained; few wetlands	Closed Mixedwood Forest	Few large shallow lakes
Glacio-fluvial Plain	Gently undulating to gently rolling	Well drained	Closed Mixedwood Forest	Few large shallow lakes
Undulating Morainal Plain	Undulating	Well to moderate, well drained	Groveland	Few large shallow lakes

Figure 1.2.2 Physiography of the Study Area

for their vegetation, soils, and surficial material characteristics. These characteristics were grouped into one of ten ecological units based on moisture and erosional status (Figure 1.3). These units were described in transect fashion for each shoreline type occurring on the lake.

Each lake was mapped using panchromatic black and white aerial photographs at scales ranging from 1:15 000 to 1:30 000 to determine:

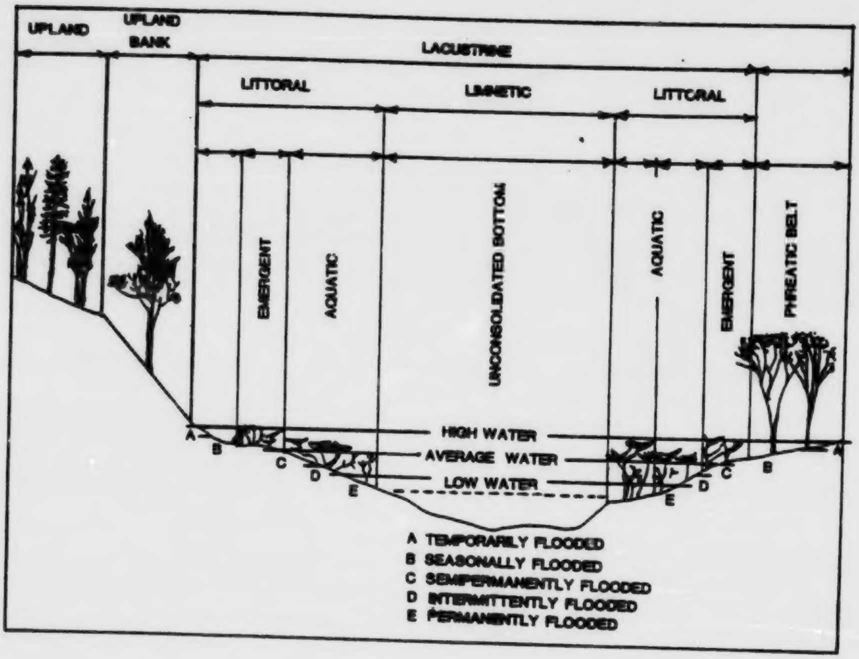
(a) ecological units around the lakes

(b) the linear extent of each shoreline type

All shoreline types and their special locations are given in Appendix II.

Each shoreline type was evaluated for lake level deviations from the median (data supplied by Alberta Environment) of .2, .5 and 1 m to determine the effects on materials, soils, and vegetation. In the next two sections this process will be qualitatively summarized. More quantitative estimates are included in Volume II of this report and in the references cited.

These predictions were in turn evaluated by the project team to determine the effects of these changes on fish, wildlife, waterfowl, and recreation.



Zone	Moisture Status	Erosion
Upland	Rapidly to moderately well drained	Uninfluenced by lakes
Upland Bank	Rapidly to imperfectly drained	Wave action controls some of the erosion processes affecting the unit; sporadic
Phreatic Belt	Imperfectly to poorly drained due to groundwater discharge or water table fluctuation	Erosion process may be locally important; however, low slope inhibits material movement; sporadic
Ice Push	Rapidly to imperfectly drained	Accretion due to ice push; sporadic
Lake Margin	Rapidly to imperfectly drained; land interface with water	Wave action and lake level responsible for accretion/erosion process; continuous
Emergent	Poorly to very poorly drained, water interface with land 0-.5 m of standing water	Wave action responsible for accretion/erosion process; continuous
Ice Scour	Water interfaces with land	Erosion due to ice push; sporadic
Aquatic I	.5-1 m standing water	Accretion/erosion controlled by circulation patterns and wave action; continuous
Aquatic II	1-2 m standing water	
Aquatic III	2 m + standing water	

Figure 1.3 Ecological Units in the Study Area

2.0 THE SHORELINES: A SUMMARY

The shorelines of the thirteen selected lakes are discussed in considerably more detail in Volume II; Appendix II. This section is to be considered as a generalized synthesis of those shoreline types for the purpose of project overview and impact assessment.

2.1 Armored Shores

2.1.1 Origin

These shorelines are characterized by a cobbly cover of the surficial materials at the lake margin. The cobbles originate within the lake shore morainal deposits which have been worked by wave-action, removing fine materials. The cobbles act to retard any further lake margin erosion.

2.1.2 Topography and Vegetation

Onshore, these shorelines range from 5-30% slopes and are generally treed or shrubbed. Off shore, slopes range from 3 to 10% and depending upon the lake bottom type, support moderately dense aquatic macrophyte growth (clay) or sparse growth (sand).

2.1.3 Susceptibility to Water Level Fluctuation

These shorelines are the least susceptible to changes due to minor water level fluctuation. However, if the cobble armor is overtopped (generally .5 m above the median lake level) increased erosion will occur with a consequent increase in falling and dead trees along the shoreline.

2.2 Phreatic - Organic Shores

2.2.1 Origin

Phreatic and organic shorelines are developed over nearly level lacustrine sediments which occur at and just above the present lake level.

2.2.2 Topography and Vegetation

These shorelines are nearly level off-shore and on. Slopes are generally 1% or less. On-shore shrub vegetation is dominated by willow, alder, and birch. Off-shore, dense aquatic macrophyte beds and emergent beds are common.

2.2.3 Susceptibility to Water Level Fluctuation

These shorelines tend to be very susceptible to changes in the water level. Increases of .5 to 1 m can flood 200 - 300 m of shrubland. Where this occurs over winter (especially during thawing or freezing) this vegetation could be eliminated.

Decreases of .2 m can result in the exposure of 20 m of sediment and the elimination of aquatic plant beds.

2.3 Sandy Shores

2.3.1 Origin

These shorelines are a result of several different processes in the area. They are common in glaciofluvial materials and occur in sandy morainal materials as well. The shorelines are characterized by the occurrence of sand at the lake margin and the absence of cobbles. Due to this absence of cobbles, sandy shores tend to erode at a much faster rate than armoured ones.

2.3.2 Topography and Vegetation

The slope of sandy shores range from 5 to 30% on-shore but are usually 1% or less off-shore. On-shore areas tend to be treed or shrubby while off-shore areas support moderately dense to dense emergent and aquatic vegetation.

2.3.3 Susceptibility to Water Level Fluctuation

These shores tend to erode (especially when steeply sloping 30%) with water level increases of .2 m or more. Decreases in water levels can eliminate large areas of emergent and macrophyte growth.

2.4 Sandy Beach Shores

2.4.1 Origin

These shores are formed when sandy materials are transported by rivers and deposited across the mouth of the river as it enters into the lake. Generally, sand beaches are formed when these materials are deposited on the windward side of the lake where they are reworked by wave action into beach ridges.

2.4.2 Topography and Vegetation

Slopes range from 10 to 30% on-shore and from 3 to 10% slope off-shore and are largely unvegetated.

2.4.3 Susceptibility to Water Level Fluctuation

Elimination of beaches by flooding generally occur at .5 m to 1 m increase in lake level. Beaches are largely unaffected by decreases in lake levels.

2.5 Summary

These shoreline types are summarized for each lake in the inventory in Table 2.5.

Table 2.5

SHORELINE SUMMARY OF SELECTED LAKES IN THE COLD LAKE REGION

Lake	Perimeter (km)	Lake Bottom Type	Shoreline Type (% of Shoreline)			
			Armoured	Phreatic-Organic	Sandy	Sand Beach
Angling	8.2	Clay	72	28		
Burnt	9.3	Sand	30	70		
Caribou	13.8	Sand	25	75		
Ethyl	8.1	Clay		50	45	5
Long Bay	10.4	Clay		100		
Manatoken	12.0	Sand	5	75	15	5
Marie	18.4	Sand	85		10	5
May	7.6	Sand	60	30	10	
Moose	61.5	Sand	40	5	40	15
Muriel	41.5	Clay	75	5	15	5
Reita	12.2	Clay	45	55		
Tucker	12.1	Clay		25	70	5
Wolf	45.1	Sand	50	30	10	10

3.0 THE LAKES

The thirteen lakes of this study were selected because they maintain, on a yearly basis, a throughflow high enough for meaningful storage.

The morphometric and hydrologic characteristics of the lake area are summaried in Table 3.01. Maximum and minimum fluctuation in lake levels are summaried in Table 3.02.

Each lake has its own unique physiography, ecological conditions, present use and susceptibility to lake level fluctuations. These are discussed individually for each lake in Section 3.2-3.13. The findings are summaried in Table 3.14.

Table 3.01

MORPHOMETRIC AND HYDROLOGIC CHARACTERISTICS

Lake[1]	Lake Surface Area (km^2)	Volume (m^3)	Maximum Depth (m)	Mean Depth (m)	Drainage Area* (km^2)
Angling	5.85	32 230	10.76	5.5	214.38
Burnt	4.43	16 890	5.08	3.7	141.33
Caribou	4.45	3 910	99.6	0.88	
Ethel	4.83	32 021	30.0	6.6	537.23
Marie	36.21	510 540	6.85	14.1	384.04
May	3.02	16 870	14.0	5.6	209.80
Moose	38.59	228 350	20.6	5.3	795.91
Muriel	63.27	449 930	11.4	6.6	438.72
Reita	12.48	28 741	4.0	2.5	55.79
Tucker	7.22	21 133	7.7	2.9	311.32
Wolf	30.74	289 500	38.3	8.2	693.06

* excluding lake surface area

[1] data for Long Bay was not available at time of writing

Table 3.02

NATURAL LAKE LEVEL FLUCTUATIONS AS MEASURED BY ALBERTA ENVIRONMENT

Lake	Recorded Lake Level (m a.s.l.)		
	Minimum	Maximum	Mean
Angling	556.777	557.394	------
Burnt	------	------	------
Caribou	------	------	------
Cold	534.704	536.058	------
Ethel	540.671	541.353	------
Manatoken	554.995	556.100	------
Marie	573.443	574.240	------
May	99.328	99.705	------
Moose	532.885	533.504	------
Muriel	559.573	560.213	------
Reita	------	------	------
Tucker	552.900	553.863	------
Wolf	597.134	597.716	------

------ data not available

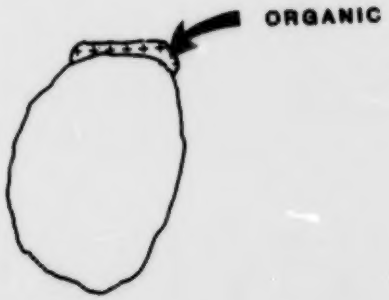
3.1 Angling Lake

Physiography

Angling Lake is bisected by the junction of two morainal plains, one gently undulating to undulating and one undulating to moderately rolling (Kocaoglu 1975). The lake is supported by river and local groundwater flow. Its most probable origin was as an ice scour during the Wisconsinan. Angling Lake receives some of the outflow of Reita Lake and then drains into the Beaver River. Its lake level fluctuation is median for the study area at about .8 m.

Ecological Conditions

The lake is surrounded by agricultural land (0-5% slope) although most of its borders are treed. The silty clay lake bottom is optimal for aquatic macrophyte growth which occurs to about 180 m from the lake margin. A small area of organic deposit with shrub vegetation occurs at the north end of the lake.



ANGLING LAKE

Present Use

The lake has a very steep boat launch on its eastern side which appears to be little used. A small and very unattractive campground also exists on the eastern shore.

Susceptibility to Lake Level Fluctuation

The lake is susceptible to the lowering of levels especially beyond .2 m. Some flooding will occur but will not be extensive with level increases up to .5 m. Any increase above .5 m would flood existing agricultural land.

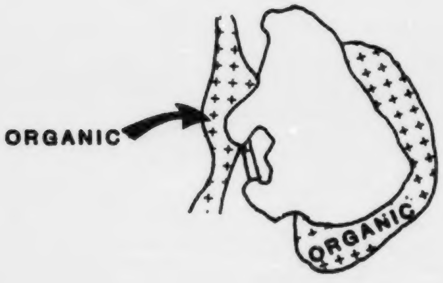
3.2 Burnt Lake

Physiography

Burnt Lake is one of the smaller lakes in the study area. It is a depressional lake supported by groundwater flow from surrounding wetlands. Its natural lake level fluctuation has not been monitored, but is expected to be about .8 m, median for the study area.

Ecological Conditions

The lake is surrounded by forest and wetlands (organic). Aquatic beds were not surveyed on this lake, but are expected to be extensive along organic shorelines. Some emergent vegetation along the western shores is apparent in the air photographs. Adverse algae blooms are also evident (July 22, 1978).



BURNT LAKE

Present Use

No development of any kind occurs in this lake. It occurs on the flyway in the Cold Lake Weapons Range.

Susceptibility to Water Level Change

Extensive flooding of wetland areas will occur with a 1 metre raise in water levels. Reduction of water levels below .2 metres will likely eliminate the emergent zone of this lake and would reduce submergent beds.

3.3 Caribou Lake

Physiography

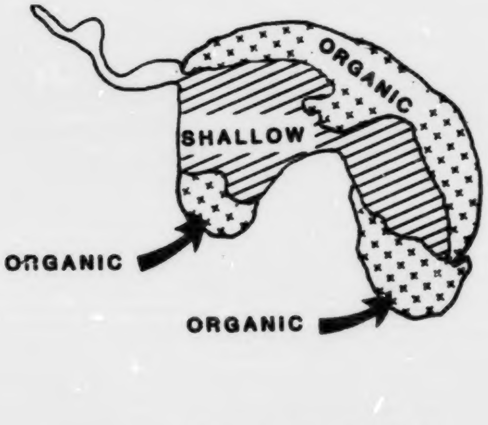
Caribou Lake is one of the smaller lakes in the study area. It is a depressional lake supported by groundwater flow from the extensive surrounding wetlands. Its natural lake level fluctuation is not monitored; however, it is expected to be low (.2-.5 m) when compared with other lakes in the study area.

Ecological Conditions

Surrounding the lake is extensive treed and untreed muskeg. The lake has not been surveyed, but due to its shallow basin it likely supports extensive aquatic macrophyte growth and emergent vegetation.

Present Use

No development of any kind occurs on this lake; however, it is located within the Cold Lake Weapons Range.



CARIBOU LAKE

Susceptibility of Water Level Change

Any fluctuation in lake levels from normal will likely cause major changes in biota. Water level reduction will expose large expanses of the lake bottom. Water level increases will flood vast areas of muskeg.

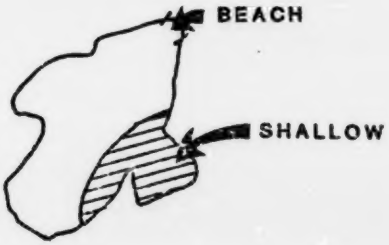
3.4 Ethel Lake

Physiography

Ethel Lake is one of the smaller lakes in the study area with an area of 4.6 square kilometres and a maximum depth of 27 metres (quite deep for such a small lake).

Ecological Conditions

The lake is surrounded by forests with some poor agricultural land (frequently flooded) to the south. The southeast bay is very shallow and contains lush aquatic macrophytes and emergent flora. The rest of the lake is ringed with an emergent zone with extensive, but somewhat less lush aquatic macrophyte beds.



Present Use

The lake supports a campground on its northeast corner (labelled beach) and is extensively used by fishermen. Some cottage development occurs on its northeast shore. On the northwest shore occurs the Esso heavy oil pilot project. Some grazing lands occur to the south of the lake.

Susceptibility to Change in Water Level

The southeast bay is especially susceptible to any lowering of water levels. Raised water levels will likely cause some flooding of agricultural land to the south at about .5 + metres.

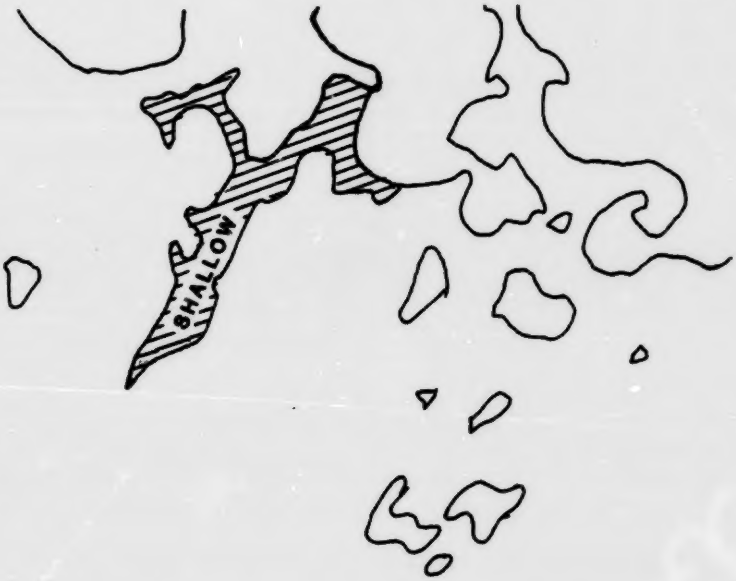
3.5 Long Bay, Cold Lake

Physiography

Long Bay is only a small portion of Cold Lake occurring on its southwest corner. The bay is very shallow with its level corresponding to that of Cold Lake.

Ecological Conditions

The bay is surrounded primarily by woodland with some agricultural land occurring to the west. Shorelines have extensive areas of wetland grading to thick Scirpus and Typha beds with a dense, lush aquatic macrophyte population occurring throughout the bay.



COLD LAKE - LONG BAY

Present Use

The bay abuts upon Cold Lake Provincial Park and is part of its nature interpretation program. It also provides spawning grounds for some of the species caught by fishermen in Cold Lake proper. Finally, two large homes occur on the south end of the bay, one of which is used as a float plane centre.

Susceptibility to Water Level Change

This bay is very susceptible to increases or decreases in water level. Large expanses of this shallow bay will be exposed with water drained on eliminating emergent and aquatic vegetation. Lake level increases will flood large phreatic areas and could adversely affect the existing two homes on the lake.

3.6 Manatokan Lake

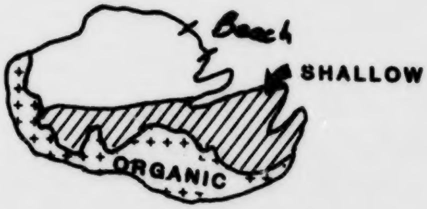
Physiography

Manatokan Lake is one of the smaller and shallower lakes of the study with an area of 4.1 km^2, an average depth of 2 m and a maximum of 4.6 m. The lake is part of the Manatokan Creek Drainage Basin which drains into the Beaver River. Manatokan Creek provides both inflow and outflow to the lake. These waters are supplemented by groundwater flow giving Manatokan Lake the highest lake level fluctuation (up to 1.9 m) of any lake in the study.

Manatokan is located within the undulating morainal plain land unit (Kocaoglu 1975).

Ecological Conditions

The lake is surrounded by agricultural land although shorelines to the north are wooded while those to the south are generally shrubby with sedge meadows intermixed. The lake has a very shallow (.2-.5 m) bay to the east which contains a lush growth of aquatic macrophytes and emergent vegetation.



MANATOKAN LAKE

The south shore of the west bay is also dominated by emergent and lush aquatic macrophytes. The north shore contains similar but less prolific communities.

Present Use

The lake is surrounded by agricultural lands used mostly for hay production and cattle grazing. On the east shore of the west bay there are a small campground and beach.

Susceptibility to Lake Level Change

The east bay is very sensitive to lake level fluctuations. Increases or decreases in lake levels over extended periods can eliminate the molting grounds.

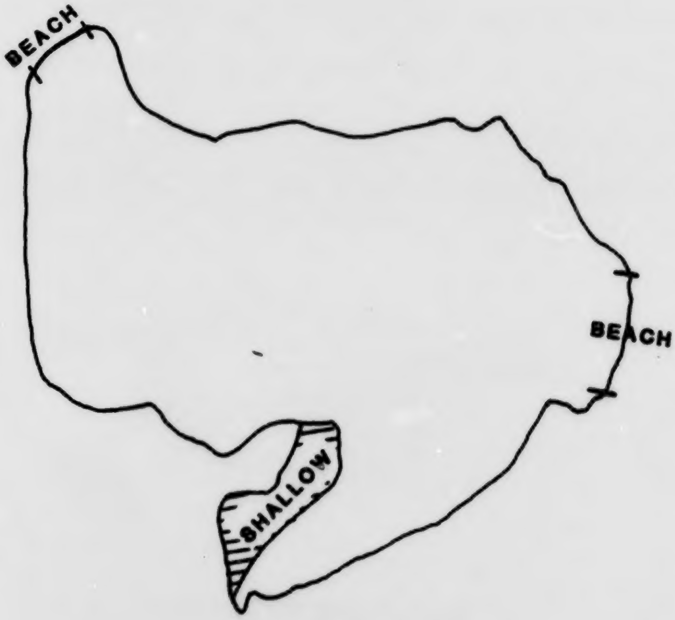
3.7 Marie Lake

Physiography

Marie Lake is one of the larger lakes in the study with an area of 33.3 square kilometres and a maximum depth of 21 metres. The lake originated during the Wisconsinan glaciation as an ice scour.

Ecological Conditions

The surroundings of the lake are largely wooded with some beach formation. Wetlands are extensive to the north and west of the lake with Cold Lake a few kilometres to the east. This has resulted in a stable water regime of ± .3 m fluctuation around the median over the last 20 years. Only one relatively shallow area occurs in the entire lake providing the major source of submergent and emergent communities.



MARIE LAKE

Present Use

The lake is used for fishing, camping and cottaging.

Susceptibility to Change in Water Level

A rise in water levels of above .5 m will likely influence cottaging and camping facilities (termed "beach" to "shallow") in the insert map. A lowering of water levels below .2 m will likely result in some change in the area marked "shallow".

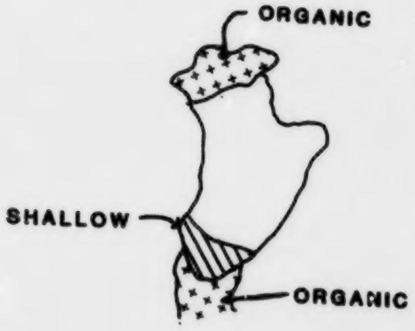
3.7 May Lake

Physiography

May Lake is the smallest lake in the study. It is a depressional lake supported by groundwater flow from surrounding wetlands. No monitoring of the lake levels occurs on this lake; however, it is expected to have a median (.8 m) natural variation.

Ecological Conditions

The lake is surrounded by forest and wetlands (organic). Aquatic beds were not surveyed on this lake but they are expected to be extensive only in the shallows at the south end of the lake and along the western shore. Emergents are also likely to occur along that shoreline.



MAY LAKE

Present Use

No development of any kind occurs on this lake. It occurs under the fly path within the Cold Lake Weapon Range.

Susceptibility to Water Level Changes

Raising lake levels above .5 m will flood extensive areas of wetland. Lowering lake levels by more than .2 m will restrict aquatic macrophyte beds.

3.9 Moose Lake

Physiography

Moose Lake occurs in a complex topography between two land units (Kocaoglu 1975): (1) undulating morainal plain to the east, and (2) a glaciofluvial plain to the west.

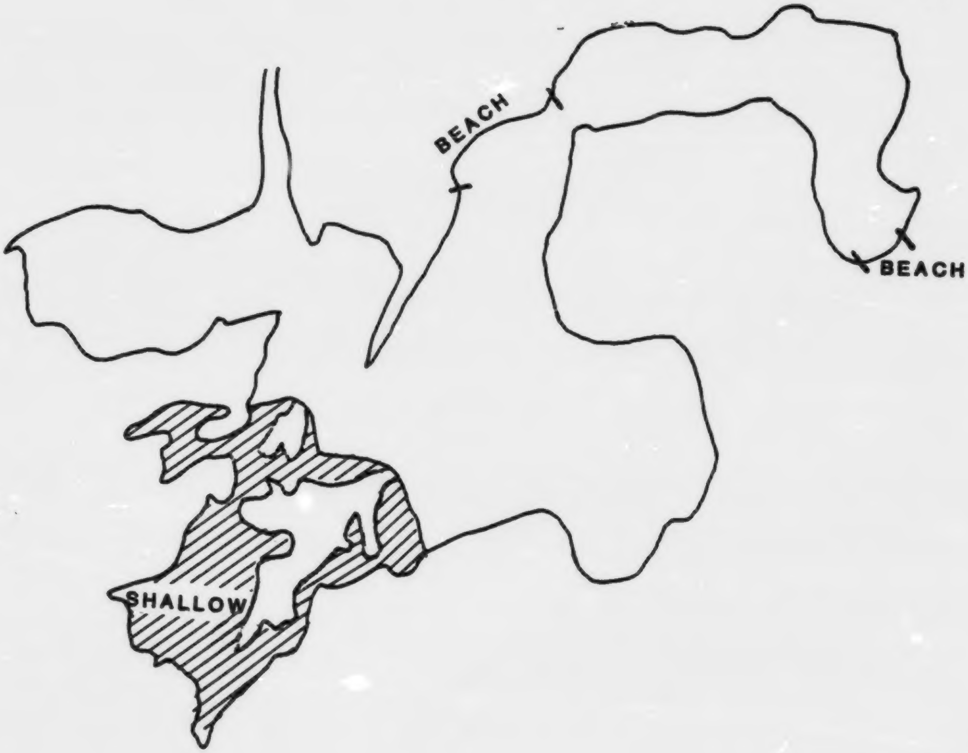
On the eastern shores, materials are calcareous (high calcium) fine loamy with cobbles and boulders interspersed. Because of the high clay and calcium content, these materials are very cohesive and resistant to erosion. To the west, glacio-fluvial materials are sandy and loose with little cohesive strength to resist surface erosion.

Moose Lake drains through the Moonslide River into the Beaver River. It has a lake level fluctuation of .6 m, about median for the lakes of the study.

Ecological Conditions

The borders of Moose Lake are largely forested except in the southwest portion where scrub and meadow vegetation make up a considerable portion of the shoreside communities.

Aquatic and emergent vegetation,lush throughout the shallow southwest bay,are confined to within 100 m of the shore throughout the rest of the lake.



MOOSE LAKE

Present Use

The lake occurs very close to Bonnyville (within 1 mile) and has a heavy recreational pressure, both from cottagers and campers. Moose Lake Provincial Park occurs along the north shore of the lake and contains camping and boat launch facilities along with extensive beaches. There are 3 other boat launches occurring along the western and southern shores of the lake.

The lake supports the largest cottage development of any in the study, some of which will be affected by any changes in water level.

Susceptibility to Lake Level Fluctuation

Any reduction in lake levels will change the southwest bay area, restricting aquatic and emergent vegetation. In addition, some cottagers are likely to see their shorelines recede by as much as 100 m.

Increased lake levels will flood cottages (.2 m from the median) along the northwest arm and south shore, as well as some of the beaches of the provincial park to the north.

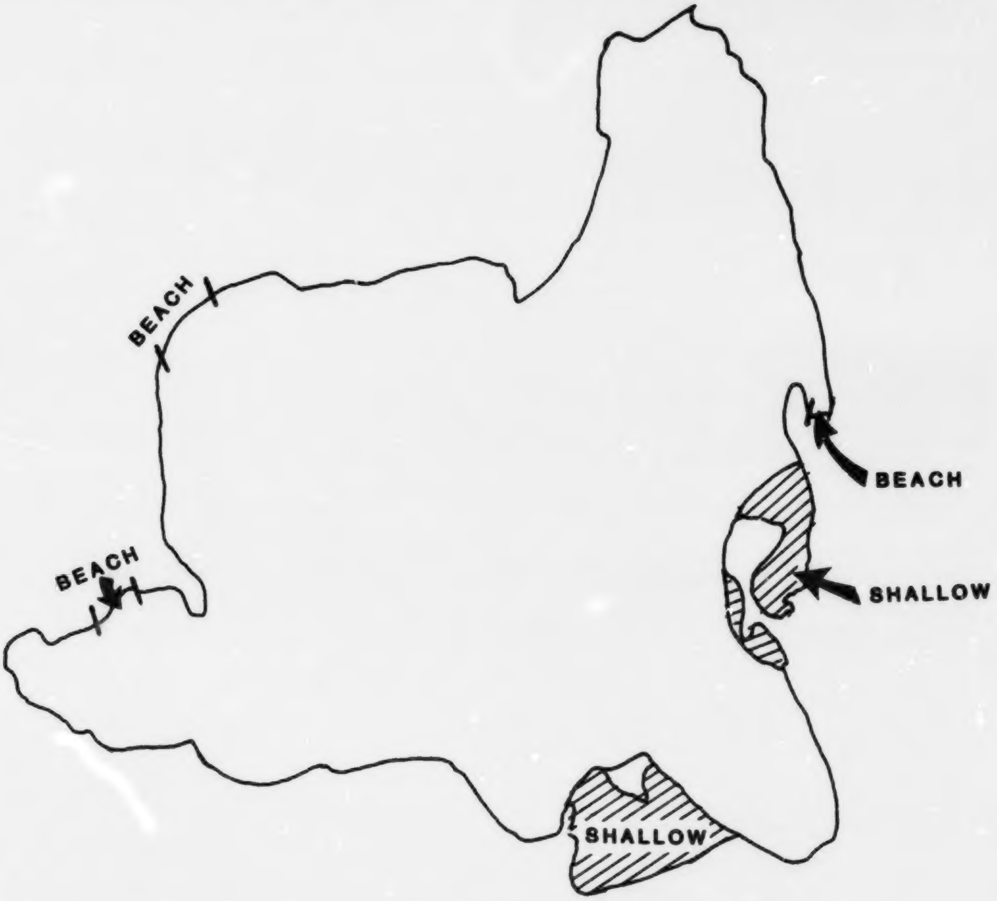
3.10 Muriel Lake

Physiography

Muriel Lake is the largest lake of the study with an area of 33.25 km^2. The lake occurs between three different morainal plains: (a) hummocky moraine, (b) rolling, and (c) undulating (Kocaoglu 1975). Lake level fluctuations are .4 m over the hydrograph period, one of the smaller level fluctuations of the study. Muriel Lake drains through Muriel Creek into the Beaver River.

Ecological Conditions

The lake is surrounded by forests dominated by aspen. Slopes into the lake are frequently steep (9-30%) along its northern and eastern shores. The silty clay bottom of the lake is optimal for aquatic plant growth and a reasonable lush growth has resulted. There are two areas of shallows on the east and southeast border of the lake.



MURIEL LAKE

Present Use

The lake supports extensive recreational cottaging along its shores. Some agriculture also occurs near shorelines.

Susceptibility to Lake Level Fluctuation

Increases in lake level of .2 m will have little effect on the lake communities. Raises above that level will likely begin to flood some recreation areas.

The lake is particularly susceptible to lowering of levels, primarily in the shallow eastern portions of the lake. Drops of .2 m or less will likely cause little vegetation change.

3.11 Reita Lake

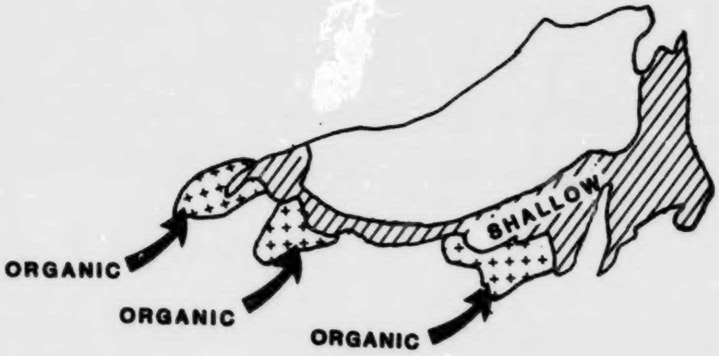
Physiography

Reita Lake is one of the smaller lakes of the study area. The lake is relatively shallow with its level supported primarily by river inflow and local groundwater. Lake level fluctuations vary about .2 m in this lake, the smallest fluctuation in any of the lakes in the study.

Reita Lake occurs in the rolling morainal plain land unit (Kocaoglu 1975) and drains through Angling Lake to the Beaver River.

Ecological Conditions

The lake is largely wooded with agricultural development to the south and east. The aquatic and emergent flora of the lake are lush, especially along the southern shore.



REITA LAKE

Present Use

The lake has no access and is not used recreationally. Agricultural development is limited to the southeastern and eastern shores.

Susceptibility to Lake Level Fluctuation

The southern, western, and eastern shores of the lake are very susceptible to lake level fluctuation (less than .2 m). Flooding or desication of the sensitive and lush phreatic, emergent, and aquatic flora will cause many changes in species composition.

3.12 Tucker Lake

Physiography

Tucker Lake occurs in a complicated topography with aeolian plains to the west, large glaciofluvial terraces to the north and till and organic materials to the south, north, and east. The lake occurs in the rolling morainal plain land unit (Kocaoglu 1975). The lake level varies about .5 m, slightly less than most of the lakes in the study.

Ecological Conditions

The lake shores are largely forested with some organics on the northwest corner. Aquatic and emergent vegetation are lush along the lake shore with an extensive macrophyte bed occurring in the northeast corner.

TUCKER LAKE

Present Use

The present use of the lake is restricted to fishermen. Access to the lake is particularly difficult and it is expected that use would increase were access improved. There are a boat ramp and picnic site on the western side of the lake.

Susceptibility to Lake Level Change

Rises in lake levels by .2 to .5 m would cause some flooding of organic areas. Increases beyond that level would severely increase erosion. Decreases in lake levels by .2 m would only slightly limit aquatic macrophyte beds and emergent zones. Lake levels lower than .2 m would have an increasingly severe effect.

3.13 Wolf Lake

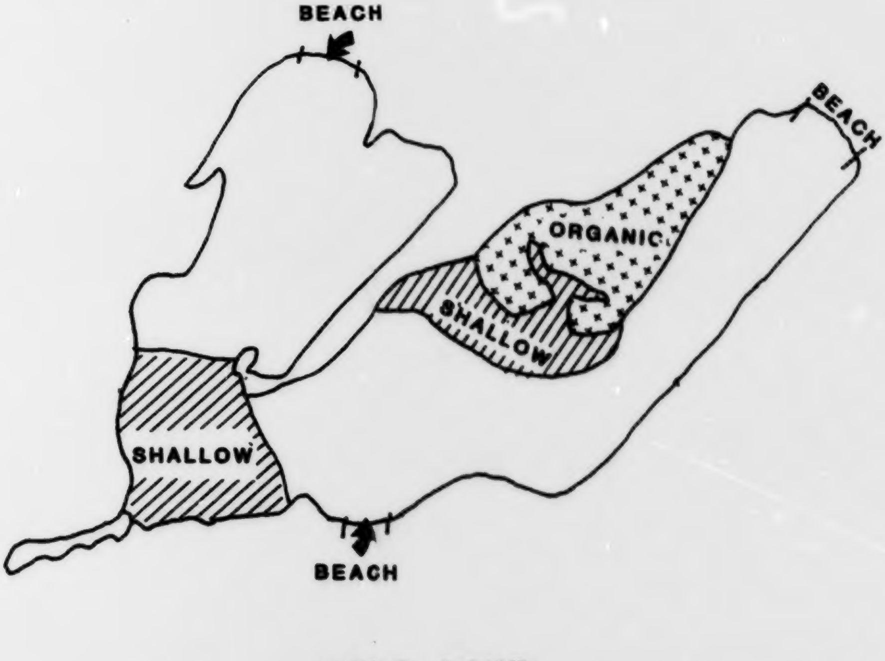
Physiography

Wolf Lake is one of the largest and deepest lakes in the study area with a maximum depth of over 40 m. Its eastern and western arms were gouged out during the Wisconsinan which deposited the material at the south end of the lake forming a large mound. Lake level fluctuations are about .3 m.

The lake drains to the west into the Sand River.

Ecological Conditions

The shores of the lake are wooded, for the most part, with a large organic deposit occurring along its north shore. There are aquatic flora throughout most of the lake with extensive emergent beds occurring on shallow sandy shelves in the southwest bay.



WOLF LAKE

Present Use

The lake supports a campground and has one access road. It is an important lake for fishing in the Cold Lake region.

Susceptibility to Lake Level Fluctuation

The emergent beds to the southwest are very susceptible to lake level fluctuation. Lowering of the lake levels below .2 m will expand a large portion of the submerged and emergent vegetation. Flooding will be less damaging; however, raises of above .5 m will flood extensive areas of organic terrain.

Table 3.14

SUMMARY OF IMPACT ON PRIMARY PRODUCTIVITY AND BEACH MATERIALS

Lake	Lake Level Increase .2	.5	1	Constraints	Lake Level Decrease .2	.5	1	Constraints
Angling	N	Mi	Ma	Flooding of agricultural areas	N	Mi	Ma	Decreased aquatic macrophyte growth
Burnt	N	Mi	Ma	Flooding of phreatic zone	N	?	?	
Caribou	Mi	Ma	Ma	Extensive flooding (20 km) of phreatic zone	Mi	Ma	Ma	Elimination of emergent and aquatic macrophyte growth
Ethyl	N	Mi	Ma	Flooding of phreatic and recreational (beach) and agricultural land	Mi	Ma	Ma	Decreased emergent and aquatic macrophyte growth
Long Bay	Mi	Ma	Ma	Flooding of extensive phreatic zones	Mi	Ma	Ma	Elimination of emergent and aquatic vegetation
Manatoken	N	Mi	Ma	Flooding of phreatic and recreation (beach) zones	Mi	Ma	Ma	Elimination of emergent and aquatic vegetation
Marie	N	Mi	Ma	Flooding of recreational (beach) zones	Mi	Ma	Ma	Elimination of emergent and aquatic vegetation
May	N	Mi	Ma	Flooding of phreatic zone	N	?	?	
Moose	Mi	Ma	Ma	Extensive flooding of phreatic and recreation (beach) zones; extensive erosion	Mi	Ma	Ma	Major decrease in emergent and aquatic macrophyte growth
Muriel	N	Ma	Ma	Flooding of recreation (beach) zones	Mi	Mi	Ma	Decrease in aquatic macrophyte growth
Reita	N	Ma	Ma	Extensive flooding of agricultural lands	Mi	Ma	Ma	Decrease or elimination of emergent and aquatic vegetation
Tucker	Mi	Ma	Ma	Extensive flooding and erosion	Mi	Ma	Ma	Decrease or elimination of aquatic macrophytes
Wolf	Mi	Mi	Ma	Flooding of beaches, extensive shoreline erosion, flooding of phreatic zone	Mi	Ma	Ma	Elimination of emergent and aquatic vegetation

N - No change
Mi - Minor change
Ma - Major change

4.0 SUMMARY

Thirteen lakes in the Cold Lake region have been inventoried for their surficial materials and vegetation growth. The impact on primary productivity by artificially increasing or decreasing the mean lake level has been predicted:

1. On a lake by lake basis (Volume I)
2. On a shoreline by shoreline basis (Volume II; Appendix III)
3. On a plant species by plant species basis (Volume II, Appendix IV) for the common species in the study area.

No lake in the inventory will escape change when water levels are changed nonetheless, some are more sensitive than others.

Among the most sensitive are Moose, Long Bay, Caribou, Tucker, Manatokan and Reita. I believe any change from the natural levels will significantly change these lakes. Indeed, some cottages on Moose Lake appear to be adversely affected under the natural regime.

Other lakes appear more sensitive to flooding than withdrawal. These include Muriel and Angling Lakes.

All other lakes, including Marie, Ethel, Burnt, and May would be more adversely affected by withdrawal.

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APPENDIX L

ECOLOGICAL INVENTORY OF LAKE SHORELINES; DETAILED REPORT

A Report Prepared By
C.A. MCGREGOR
RESOURCE APPRAISAL SECTION
RESOURCE EVALUATION AND PLANNING DIVISION
ALBERTA ENERGY AND NATURAL RESOURCES

Alberta
ENERGY AND
NATURAL RESOURCES

MEMORANDUM

FROM J.R. Harrower, Director
Resource Evaluation Branch

OUR FILE REFERENCE

YOUR FILE REFERENCE

TO R. Hicks
Athabasca Basin Planner
Planning Division
Alberta Environment

DATE May 30, 1983

TELEPHONE 427 - 3505

SUBJECT ECOLOGICAL INVENTORY OF SHORELINES OF SELECTED LAKES IN THE COLD LAKE REGION, VOLUME I and II

I am pleased to present you with our final report entitled "An Ecological Inventory of Shorelines of Selected Lakes in the Cold Lake Region, Volume I and II".

The report contains an inventory of the shorelines of 13 lakes for inclusion in your water management plan.

If you have any questions regarding the report, please contact either myself or Cameron McGregor, the study author.

Thank you for the opportunity to contribute.

J Harrower
J.R. Harrower

Attached
c.c. J.R. Prokopchuk
C.A. McGregor

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Appendix I

Ecosection Descriptions of the Cold Lake Region

Ecosection	Surficial Materials	Soils[1]	Slope (%)[2]	Internal Drainage[2]	Vegetation
8A1	Aeolian; sandy	Eluviated Dystric Brunisol (Nestow), Terric Mesisol (Manitokan)	0 - 9	Rapid	Open coniferous forest; jackpine
8F1	Outwash alluvium - sandy. Some beach formation	Eluviated Eutric Brunisol	0 - 5	Well to imperfect	Closed mixedwood forest; aspen, balsam poplar
8F2	Undifferentiated alluvium and glaciofluvial; sand to sandy clay	Undifferentiated	0 - 9	Rapidly to poorly	Open mixedwood forest; aspen, jackpine
8FQ1	Sandy fluvial outwash with organics along margins	Terric Mesisol, Terric Fibrisol, Typic Mesisol	0 - 5	Poor to very poorly	Scrub; willow
8LQ1	Lacustrine veneers overlain by organic deposits interspersed	Rego Humic Gleysol, Typic Mesisol	0 - 1	Imperfectly to very poorly drained	Open coniferous forest; black spruce, tamarack
8LQ2	Lacustrine, abandoned beach ridges with some organic veneer	Rego Humic Gleysol, Typic Mesisol	0 - 1	Poor to very poorly drained	Scrub; willow
8M1	Ground moraine; loamy sand with some fluvial on aeolian veneers	Orthic Gray Luvisol (Tomson)	6 - 9	Moderately well drained	Closed mixedwood forest; aspen, white spruce
8M2	Ground moraine; fine loamy, moderately to strongly calcareous with some alluvial sandy overlays	Orthic Gray Luvisol (La Corey, Tomson), Eluviated Eutric Brunisol (Nicot)	6 - 9	Moderately well drained	Closed mixedwood forest; aspen spruce.
8M3	Ground moraine; fine loamy, weakly calcareous; subsidence along lake shore	Orthic Gray Luvisol (La Corey), Eluviated Eutric Brunisol (Nicot) (Nestow), Rego Humic Gleysol	0 - 9	Moderately well to imperfectly drained	Closed mixedwood forest; aspen, balsam poplar, spruce

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[1] Series names from Kocaoglu (1975)

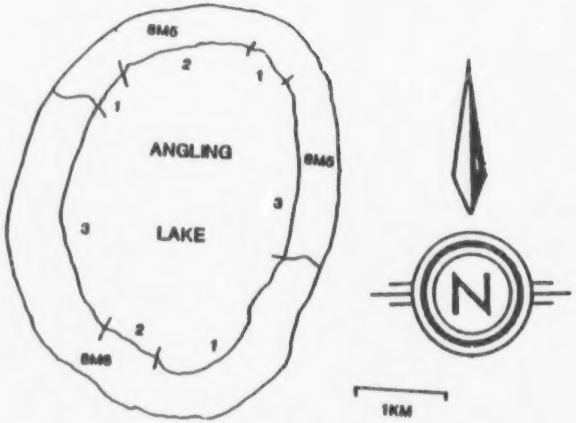
[2] Categories from CSSC 1978

Ecosection	Surficial Materials	Soils	Slope (%)	Internal Drainage	Vegetation
BM4	Ground moraine; fine loamy, moderately to strongly calcareous, rare interspersed glaciofluvial sand	Orthic Gray Luvisol (La Corey) Eluviated Eutric Brunisol (Edward)	10 - 30	Moderately well drained	Closed mixedwood forest; spruce, aspen
BM5	Ground moraine; fine loamy, moderately to strongly calcareous	Eluviated Black Chernozem (Fergy), Dark Gray Luvisol (Spedden), Humic Eluviated Gleysol (Mapova)	2 - 9	Well drained	Agricultural
BM6	Ground moraine; fine, loamy, moderately to strongly calcareous	Orthic Gray Luvisol (La Corey) Dark Gray Luvisol (Spedden)	0 - 9	Well	Agricultural
BM7	Ground moraine; fine loamy, moderately to strongly calcareous with discontinuous alluvial veneers	Orthic Gray Luvisol (La Corey) Eluviated Eutric Brunisol (Codessa)	0 - 9	Moderately well to well drained	
BM8	Hummocky moraine; fine loamy, moderately to strongly calcareous with small pockets of glaciofluvial and interspersed	Orthic Gray Luvisol (La Corey) Eluviated Eutric Brunisol (Edward)	6 - 9	Moderately well to poorly drained	Closed mixedwood forest; aspen, spruce
BM9	Hummocky moraine; fine loamy, moderately to strongly calcareous	Orthic Gray Luvisol (La Corey) Low Humic Eluviated Gleysol (Newbrook)	16 - 30	Moderately well to poorly drained	Closed mixedwood forest; aspen, spruce
BMF1	Ground moraine; sandy loam with fluvial veneers	Orthic Gray Luvisol (Tomson), Eluviated Eutric Brunisol (Nicot) and Rego Humic Gleysol (Daken)	10 - 30	Moderately well to imperfectly	Closed mixedwood forest; spruce, aspen

Ecosection	Surficial Materials	Soils	Slope (%)	Internal Drainage	Vegetation
8MF2	Ground moraine; fine loamy, weakly calcareous with sandy alluvial overlays	Orthic Gray Luvisol (La Corey) and Eluviated Eutric Brunisol (Nicot)	6 - 9	Moderately well to imperfectly drained	Closed mixedwood forest; spruce, aspen
8MQ1	Ground moraine; sandy with extensive organics interspersed	Eluviated Eutric Brunisol and Typic Mesisol	0 - 9	Moderately well to very poorly drained	Closed mixedwood forest; aspen, spruce, pine Scrub; willow, meadow; sedge
8Q1	Organic	Typic Mesisol (Manatokan)	0 - 1	Very poor	Meadow; sedge
8Q2	Organic	Typic and Mesic Humicol (Bonnie)	0 - 1	Poorly to very poorly drained	Treed muskeg; black spruce
8G1	Sandy glacio-fluvial or aeolian material	Degraded Eutric Brunisol (Lisa, loamy sand)	0 - 5	Drained rapidly	Closed mixedwood forest; aspen, jack pine, black spruce
8QF1	Organic floodplain	Terric and Terric Fibric Mesisol (Manatokan)	0 - 1	Very poorly	Meadow; sedge Scrub; birch

Appendix II

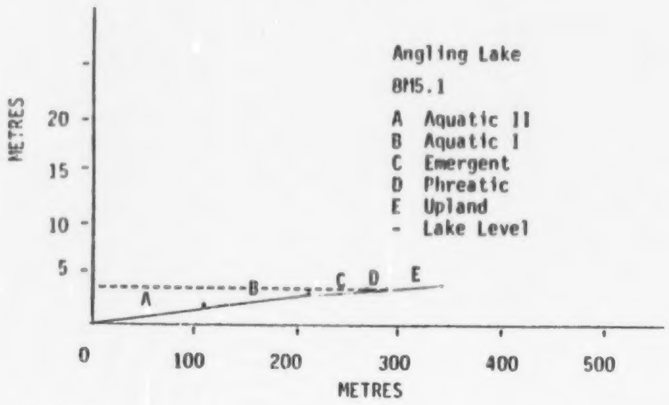
Shoreline Descriptions


BM5
2
1
1
ANGLING
BM5
3
3
LAKE
2
1
BM6
N
1KM

LAKE: ANGLING

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8M5.1	900	Aquatic II	100-120	2	4 - 2	Soft silt	D	Chara globularis (sparse)
		Aquatic I	120-100	2	2 - 1.25	Silt	D	Ceratophyllum spp., Potamogeton zosterisformis (dense)
		Emergent	60-120	1	1.25 - 0	Silt	D	Scirpus validus
		Phreatic	15-30	0-1	0 .3	Silt	D	Scrub; willow
		Upland		1			I	Agricultural

PROFILE



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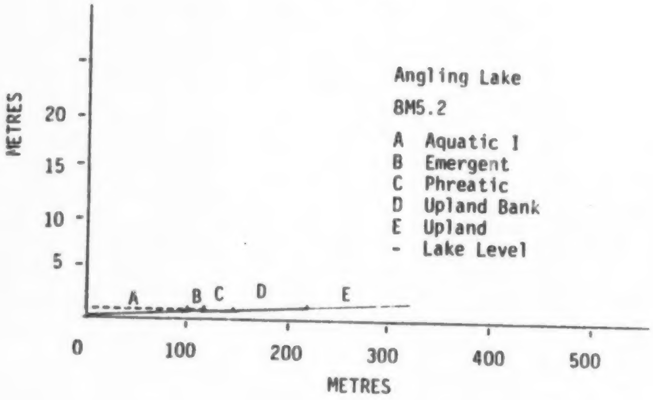
* D - Depressional
I - Inactive Erosional

LAKE: ANGLING

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8M5.2	1 400	Aquatic I	100-20	1	1.5-.25	Silt	D	Potamogeton zosterisformis (dense)
		Emergent	20-0	1	0 .25	Silt	D	Scirpus validus
		Phreatic	60	0-1	0 .6	Silt	D	Scrub; willow/sedge
		Upland Bank	120	1	1	Sand	I	
		Upland					I	Agricultural

PROFILE



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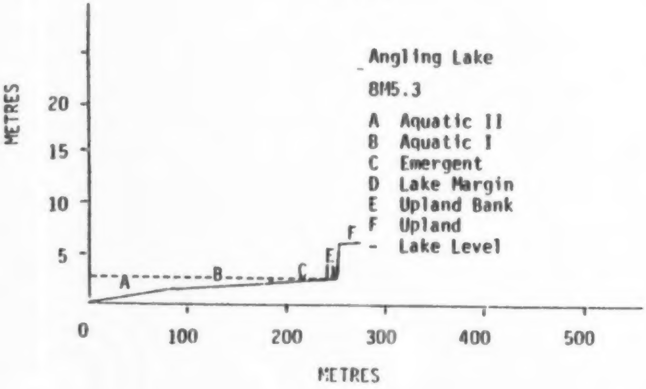
* D - Depressional
I - Inactive Erosional

LAKE: ANGLING

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8M5.3	1 600	Aquatic II	80-100	2	3 - 2	Hard sand	D	Potamogeton filformis (sparse)
		Aquatic I	100	1	2 - 1	Sand	D	Potamogeton filformis, Myriophyllum exalbescens (dense)
		Emergent	60-120	1	1 - 0	Sand	D	Scirpus validus
		Lake Margin	2	31-40	0 .5	Sand beach	E	
		Upland Bank	5	46-70	2 - 4	Till, loamy		Open aspen forest
		Upland		2-5				Agricultural

PROFILE



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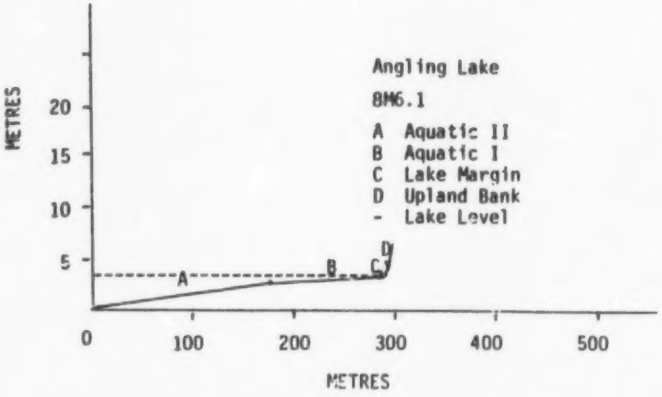
* D - Depressional
E - Erosional

LAKE: ANGLING

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8M6.1	2 000	Aquatic II	180-100	2	3 - 2	Hard sand	D	Potamogeton filformis (sparse)
		Aquatic I	100-0	1	2 - 0	Sand	D	Potamogeton filformis, Myriophyllum exalbescens (dense)
		Lake Margin	1	0-9	0.1	Sand beach	E	
		Upland Bank	5	46-70	2 - 4			Open aspen forest

PROFILE



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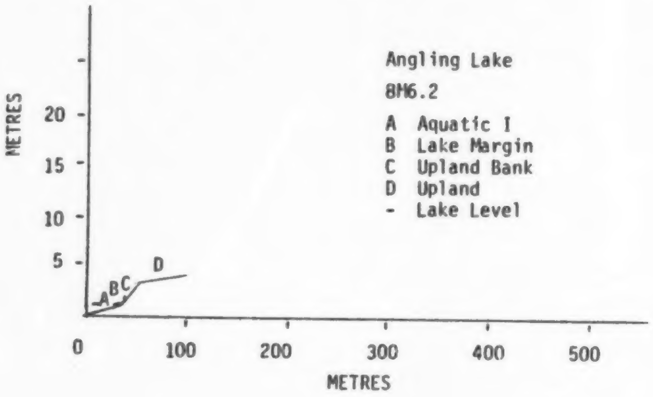
* D - Depressional
E - Erosional

LAKE: ANGLING

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status	Vegetation
8M6.2	500	Aquatic I	30-0	3	1 - 0	Hard sand		Myriophyllum exalbescens, Potamogeton filformis and richardsonii (sparse-medium)
		Lake Margin	1-5	10-15	0.2	Sandy beach		
		Upland Bank		10-15	0.3-1.3	Sand		Fireweed, bluejoint grass
		Upland		2-5		Sand terrace		Closed balsam poplar forest

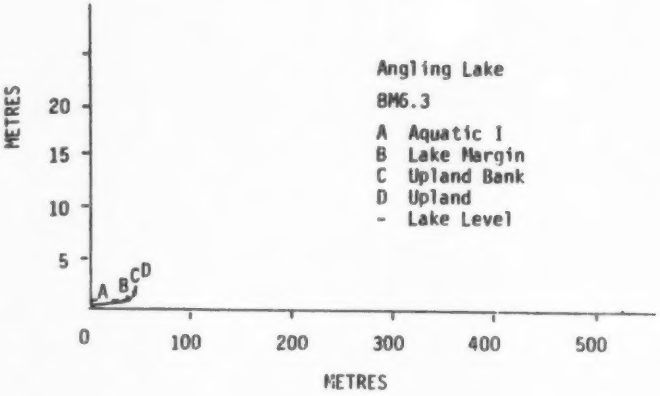
PROFILE

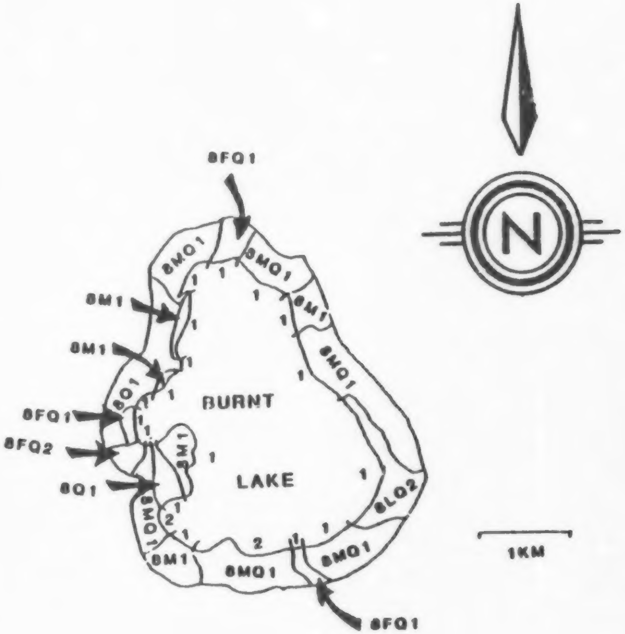


LAKE: ANGLING

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status	Vegetation
8M6.3	2 300	Aquatic I	40-0	2	1-0	Soft silt		Potamogeton richardsonii and filformis, Myriophyllum exalbescens (dense)
		Lake Margin	2	10-15	0.3	Boulders		
		Upland Bank	2	100	1.3			Scrub; poplar, willow
		Upland				Till		Agricultural

PROFILE

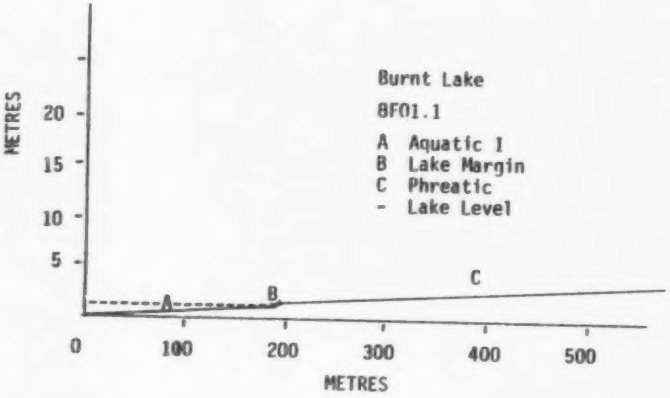



SFQ1
SMQ1
SMQ1
SM1
SM1
SM1
SMQ1
SQ1
SFQ1
SFQ2
SQ1
SM1
BURNT
LAKE
SMQ1
SM1
SMQ1
SMQ1
SLQ2
SFQ1
1
2
N
1KM

LAKE: BURNT[1]

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status*	Vegetation
8FQ1.1	1 000	Aquatic I	180 +	0 - 1	1	Sandy	D	Myriophylum exalbescens, Potamogeton spp.
		Lake Margin	1	2 - 5		Sandy beach	D	
		Phreatic	450 +	0 - 1	1	Organic	D	Meadow; sedge, Scrub; willow

PROFILE



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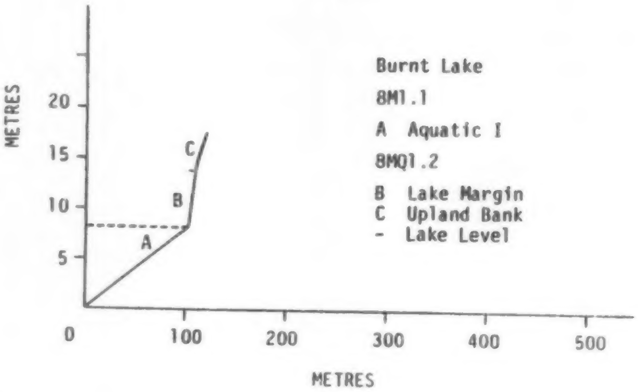
[1] These shoreline types have been interpreted from air photos and have not been ground truthed.

* D - Depressional

LAKE: BURNT[1]

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8M1.1	3 000	Aquatic I	100	6 - 9	1 - 2	Sandy	E	Sparse Potamogeton
8MQ1.2	1 500	Lake Margin	1-15	46-100	0.5	Sandy undercut	E	
		Upland Bank		30-70	5	Sandy	E	Closed mixedwood forest; aspen, spruce
		Upland					I	Closed mixedwood forest; aspen, spruce

PROFILE



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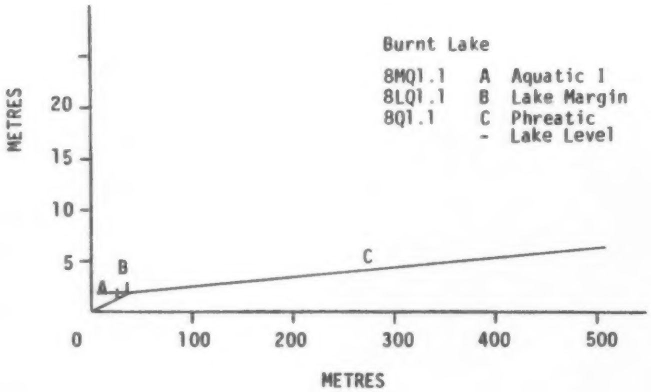
[1] These shoreline types have been interpreted from air photos and have not been ground truthed.

* E - Erosional
I - Inactive Erosional

LAKE: BURNT[1]

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status *	Vegetation
8MQ1.1	1 500	Aquatic I	50 +	2 - 5	1 - 2	Sandy	D	Sparse Potamogeton, Chara globularis
8LQ1.1	1 500	Lake Margin	10	2 - 5	0.5	Sandy beach	D	
8Q1.1	500	Phreatic	450+	0 - 1	1 - 2	Organic	D	Meadow; sedge, Scrub; willow

PROFILE



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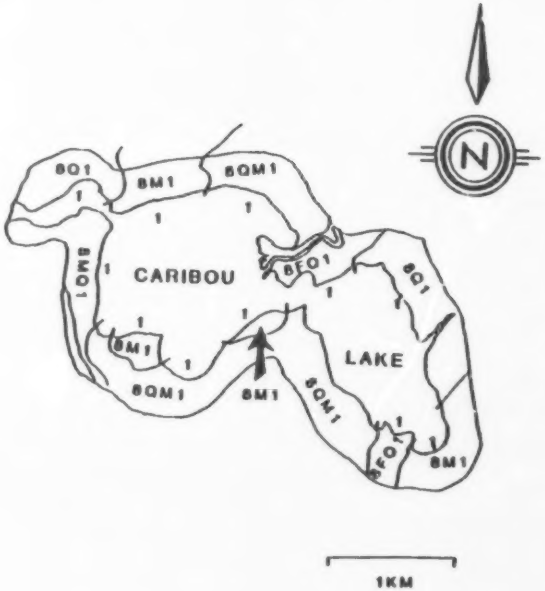
* D - Depressional

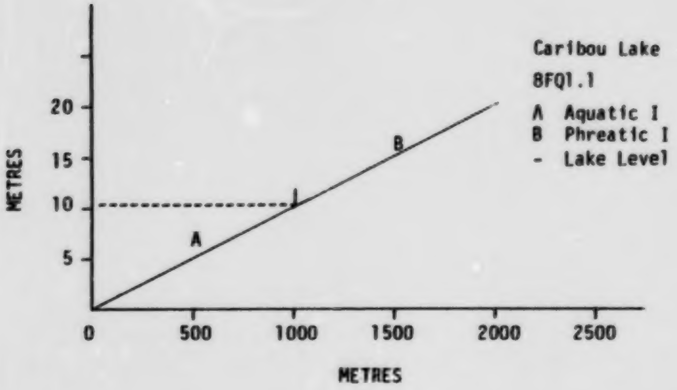
[1] These shoreline types have been interpreted from air photos and have not been ground truthed.


SQ1
SM1
SQM1
SMQ1
CARIBOU
BFQ1
SQ1
1
SM1
SQM1
SM1
LAKE
SQM1
BFQ1
SM1
N
1KM

LAKE: CARIBOU

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status	Vegetation
8FQ1.1	2 000	Similar to 8MQ1.1						

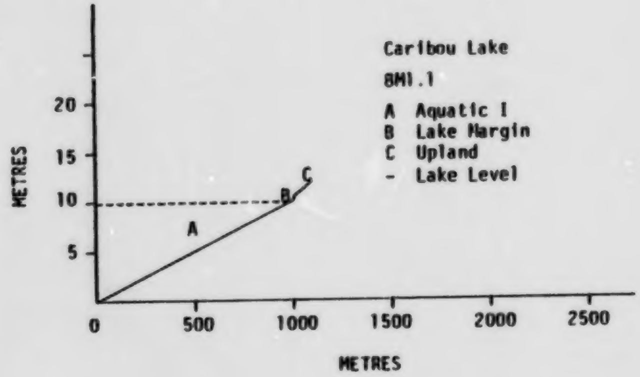
PROFILE



LAKE: CARIBOU

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8M1.1	3 500	Aquatic I	1 000	0 - 1	2 - 1	Silt	D	Myriophylum exalbescens (dense)
		Lake Margin	2	16-30	0.5	Cobbles and sand	I	
		Upland		6 - 9		Sandy till	I	Closed mixedwood forest; aspen, spruce

PROFILE



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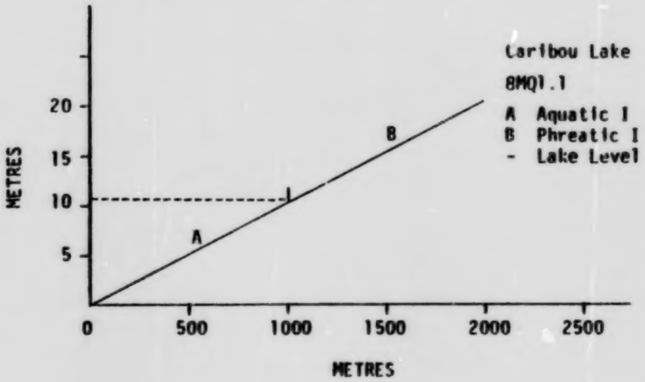
* D - Depositional
I - Inactive Erosional

LAKE: CARIBOU

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status	Vegetation
8MQ1.1	2 000	Similar to 8MQ1.1						

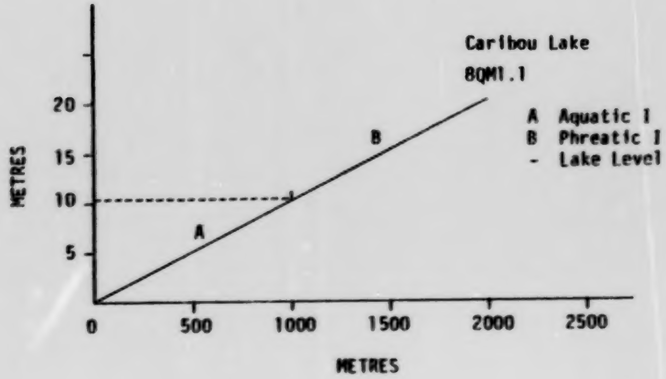
PROFILE



LAKE: CARIBOU

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8QM1.1	3 500	Aquatic I	1 000	0 - 1	2 - 1	Silt	D	Myriophylum exalbescens (dense)
		Phreatic I	1 000+	0 - 1	0 - 1	Organic intermixed with sandy till	I	Treed muskeg

PROFILE



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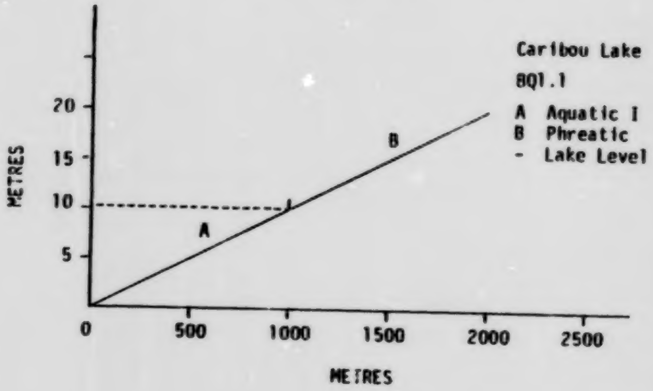
* D - Depositional
I - Inactive Erosional

LAKE: CARIBOU

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8Q1.1	2 800	Aquatic I	1000	0 - 1	2 - 1	Silty	D	Myriophylum exalbescens (dense)
		Phreatic	1000+	0 - 1	0 - 1	Organic	I	Scrub; willow

PROFILE



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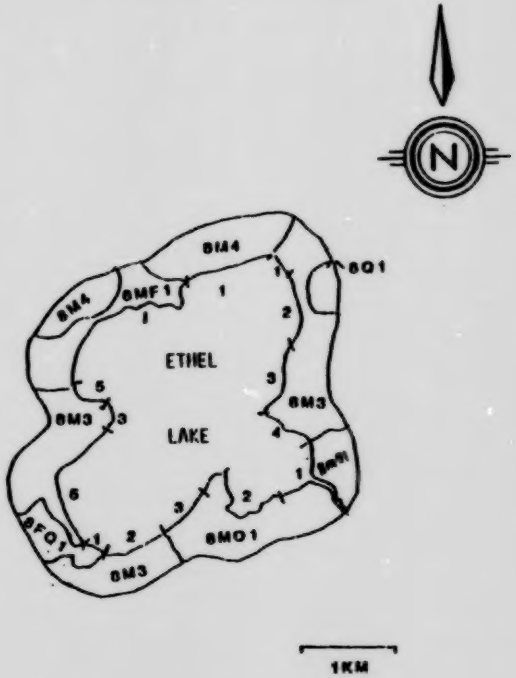
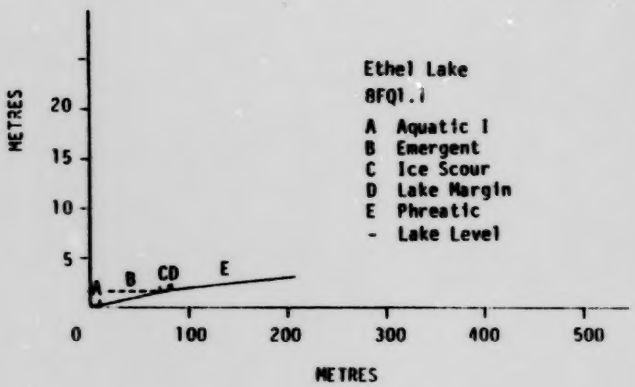
* D - Depositional
I - Inactive Erosional


ETHEL
LAKE
BM4
BM4
BMF1
BO1
BM3
BM3
BM3
BMO1
BFO1
BM3
1
1
1
2
3
4
1
2
3
2
1
5
3
5
1KM
N

LAKE: ETHEL LAKE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8FQ1.1	300	Aquatic I	10	3	2-1.75	Silt	D	Chara globularis (sparse), Potamogeton richardsonii
		Emergent	60	2	1.75-0.25	Silt	I	Scirpus validus (moderate)
		Ice Scour	10	2	0.25-0	Sand	E	Chara globularis (sparse)
		Lake Margin	2-4	6-9	0.2	Sand		
		Phreatic	100-150	0-1	1	Sand, silt and organic	D	Scrub; willow

PROFILE



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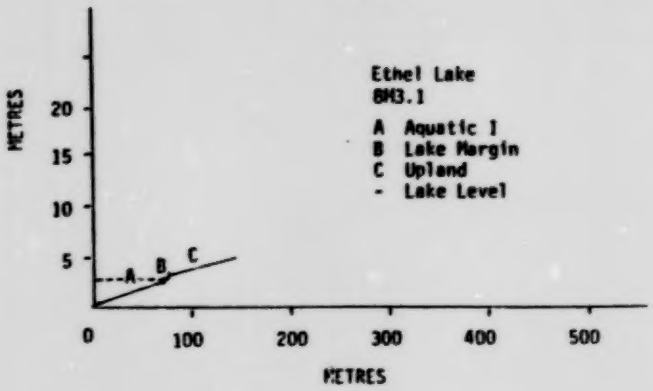
* D - Depositional
I - Inactive Erosional
E - Erosional

LAKE: ETHEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
BM3.1	350	Aquatic I	70	3-5	2	Sand	D - E	Chara globularis (sparse)
		Lake Margin	10-15	11-30	2	Sand	D - E	
		Upland		2-5				Open mixedwood forest; aspen, balsam poplar, spruce


PROFILE

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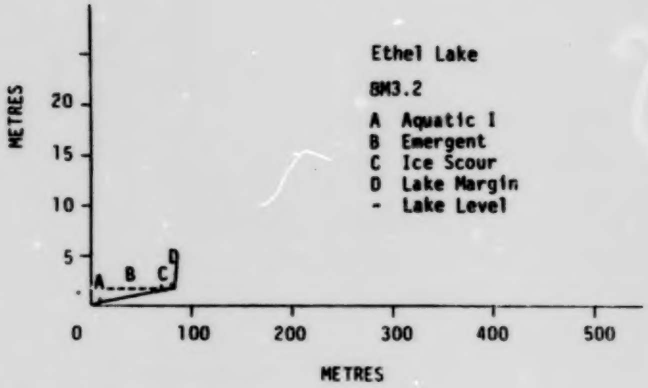
* D - Depressional
E - Erosional

LAKE: ETHEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8M3.2	700	Aquatic I	10	3	2-1.75	Silt	D	Chara globularis (sparse), Potamogeton richardsonii
		Emergent	60	2	1.75-25	Silt	I	Scirpus validus (moderate)
		Ice Scour	10	2	0.25-0	Sand	E	Chara globularis (sparse)
		Lake Margin	0.5	2-5		Undercut Sandy bank	E	
		Upland Bank	0.5	100	0.5	Sandy	E	Calamagrostis inexpansa
		Upland		2-5		Sandy Terrace		Closed mixedwood forest Aspen, agriculture

PROFILE



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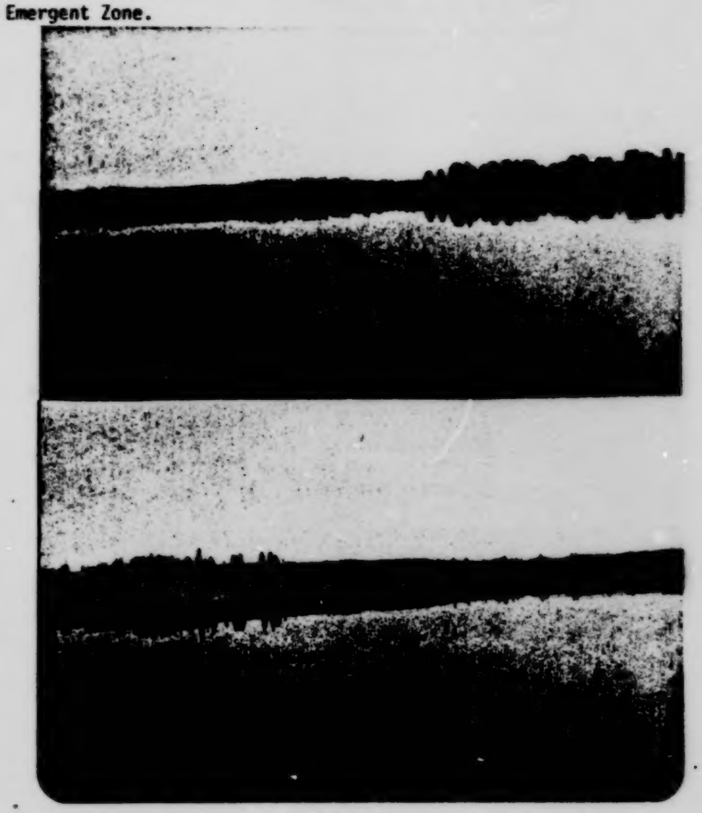
* D - Depositional
I - Inactive Erosional
E - Erosional

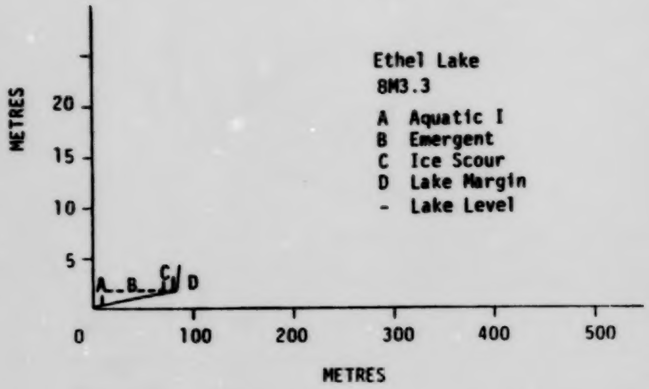
LAKE: ETHEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status	Vegetation
8M3.3	1 000	Similar to 8M3.2 with Phragmites communis occurring in the Emergent Zone.						



Shallow Bay: This is a panoramic photo of a shallow bay on the northeast side of Ethel Lake. Note the dense bed of Scirpus validus across the mouth of the bay, which barred access to it. Reliance for the shoreline type within the bay was placed on Planning Services Division, 1980.

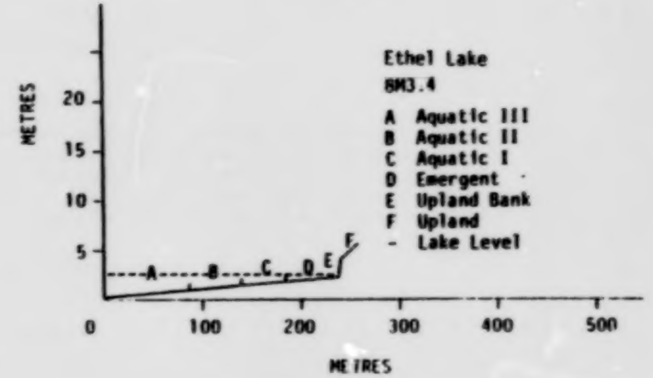
PROFILE



LAKE: ETHEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
BM3.4	500	Aquatic III	45-130	0 - 2	3 - 2	Silt	D	Potamogeton pectinatus, Potamogeton vaginatus (dense)
		Aquatic II	45-60	0 - 2	2 - 1	Silt	D	Potamogeton vaginatus, Myriophyllum exalbescens (dense)
		Aquatic I	45	0 - 2	1-0.75	Silt		Myriophyllum exalbescens, Potamogeton richardsonii (dense)
		Emergent	45-60	0 - 2	0.75	Sand	D	Scirpus validus, Nuphar variegatum, Phragmites communis
		Upland Bank	2-3	71-100	1	Sandy	E	Scrub; willow, aspen
		Upland		6 - 9		Sandy	I	Forest; aspen, spruce

PROFILE



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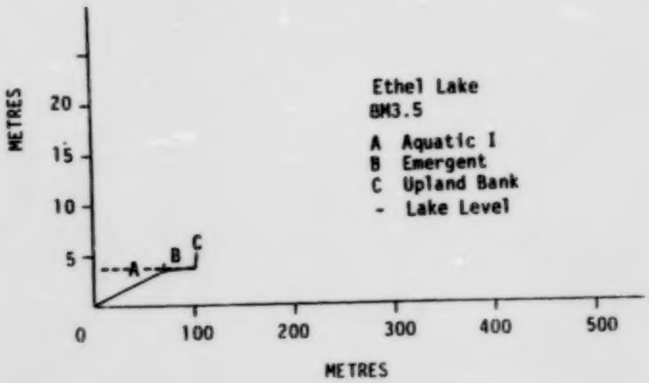
* D - Depositional
I - Inactive Erosional
E - Erosional

LAKE: ETHEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
BM3.5	1 700	Aquatic I	70	5	3	Silt	D	Potamogeton richardonii, Myriophylum exalbescens
		Emergent	15-45	0-1	0.5	Sand	D	Scirpus validus
		Lake Margin	1	10	0.1	Sand		
		Upland Bank	4	46-100	2	Sandy till	E	Scrub; birch, willow
		Upland		2-5				Closed mixedwood forest; aspen

PROFILE



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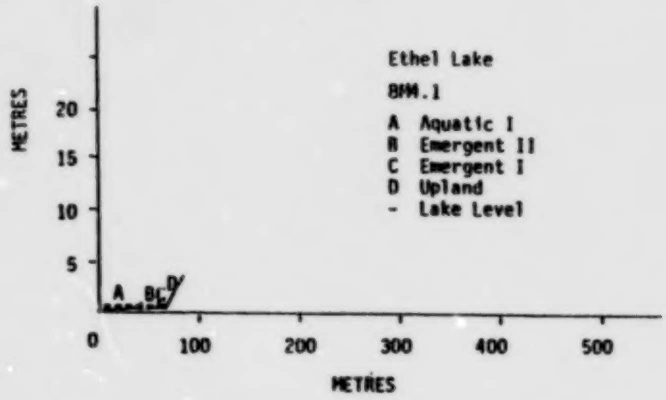
* D - Depositional
E - Erosional

LAKE: ETHEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
BHM.1	700	Aquatic I	10-50	0-1	0.2	Silt	D	Potamogeton richardsonii
		Emergent II	20	0-1	0.2	Silt	D	Scirpus validus, Nuphar variegatum
		Emergent I	5	0-1	0.1	Silt	D	Carex spp., Typha latifolia
		Upland		16-30		Sandy till	E	Disturbed

PROFILE



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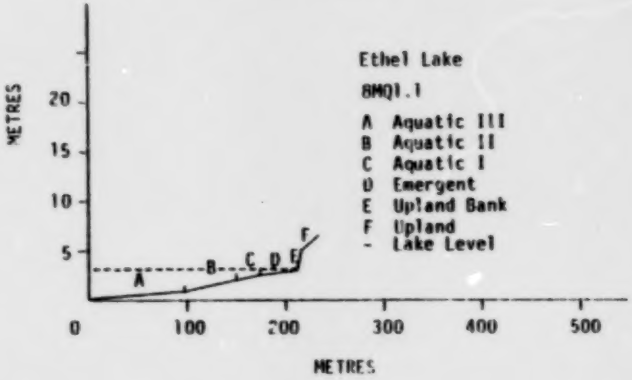
* D - Depositional
E - Erosional

LAKE: ETHEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8MQ1.1	800	Aquatic III	45-150	1	3 - 2	Silt	D	Potamogeton pectinatus, Potamogeton vaginatus (dense)
		Aquatic II	45-60	1 - 2	2 - 1	Silt	D	Potamogeton vaginatus, Myriophyllum exalbescens (dense)
		Aquatic I	15-30	1 - 2	1-0.75	Silt	D	Myriophyllum exalbescens, Potamogeton richardsonii (dense)
		Emergent	30-45	1	0.75-0	Silt and sand	D	Scirpus validus, Phragmites communis
		Upland Bank	2 - 3	70-100	1	Sandy	E	Scrub; willow
		Upland		2 - 9		Sandy	I	Closed mixedwood forest; aspen, spruce

PROFILE



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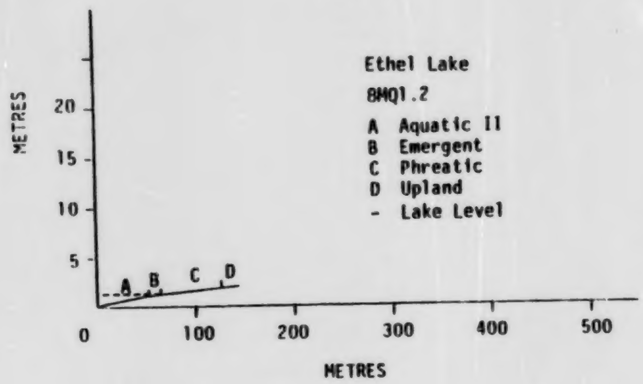
* D - Depositional
E - Erosional
I - Inactive Erosional

LAKE: ETHEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8MQ1.2	1 000	Aquatic II	45-60	2	2 - 1	Silty	D	Ceratophyllum
		Emergent	10-15	1	0.5	Silty		Typha latifolia, Carex spp.
		Phreatic	60	0 - 1	1	Sandy, organic	D	Scrub; willow
		Upland		0 - 1		Sandy	I	Closed mixedwood forest; balsam poplar, spruce

PROFILE



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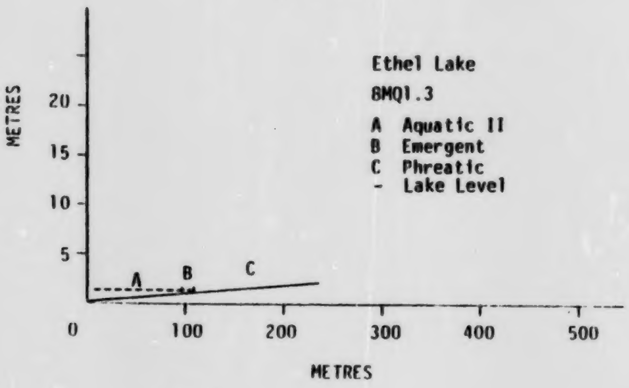
* D - Depositional
I - Inactive Erosional

LAKE: ETHEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status *	Vegetation
8MQ1.3	50	Aquatic II	45-150	1	2 - 1	Silty	D	Ceratophyllum
		Emergent	10-15	1		Silty	D	Typha latifolia, Carex spp.
		Phreatic	100-150	1		Silty	D - E	Scrub; willow, balsam poplar

PROFILE



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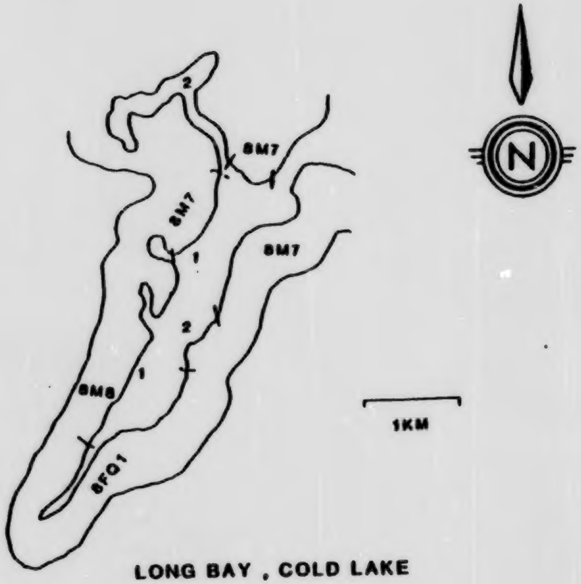
* D - Depositional
E - Erosional



LONG BAY , COLD LAKE

LAKE: LONG BAY, COLD LAKE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8FQ1.1	1 500	Aquatic and Emergent zones similar to 8M7.2						
		Phreatic	100-300	0-1	1-3	Silt, organics	D	Scrub; willow

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* D - Depositional

LAKE: LONG BAY, COLD LAKE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8M7.1	4 000	Aquatic I	60	2	1.75-1.50	Silt	D	Potamogeton zosterisformis (sparse)
		Emergent I	60	2	1.50-1.25	Silt	D	Nuphar variegatum, Sagittaria cuneata
		Emergent II	15-20	3-4	1.25-0	Silt	D	Meadow; Carex aquatilis, Typha angustifolia
		Phreatic	45-200	0-1		Silt	D	Scrub; willow, bluejoint grass
		Upland Bank	10	10-15	2	Loam	I	Scrub; willow, agricultural
		Upland		2-5		Loam	I	Closed mixedwood forest; aspen Agricultural

[redacted]

I - Inactive Erosional

LAKE: LONG BAY, COLD LAKE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status *	Vegetation
8M7.2	4 500	Aquatic I	45	1	0.75-2	Silt	D	Potamogeton zosterisformis Myriophyllum exalbescens (dense)
		Emergent I	60-120	1	0.5-0.2	Silt	D	Nuphar variegatum, Sagittaria cuneata
		Emergent II	1	1	0.2-0	Silt	D	Typha angustifolia
		Phreatic	15-65	1	0-0.5	Silt	D	Scrub; willow
		Upland		2-5		Loam	I	Closed mixedwood forest; aspen Agricultural

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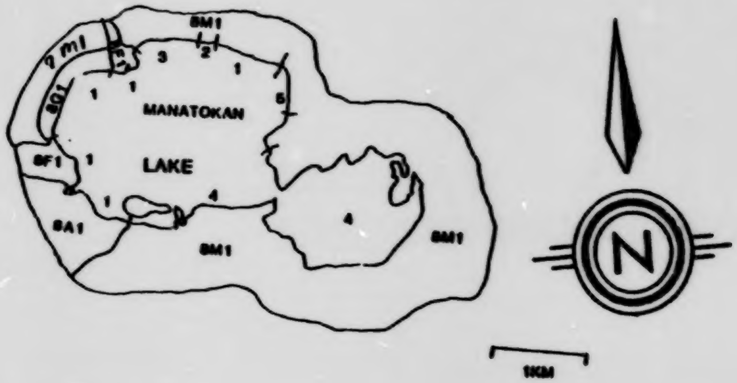
* D - Depositional
I - Inactive Erosional

LAKE: LONG.BAY, COLD LAKE

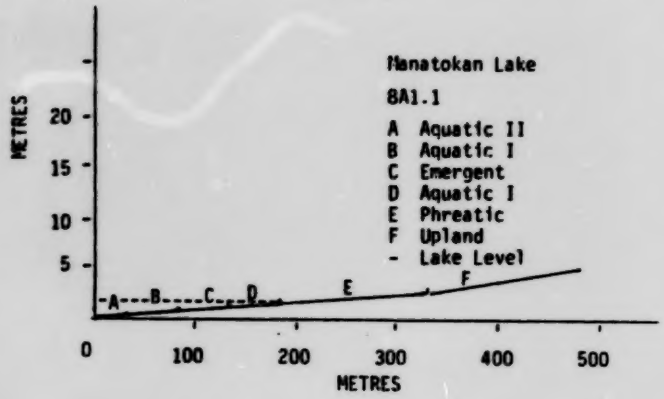
Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status	Vegetation
8M8.1	4 500	Similar to 8M7.1						


BM1
? ml
SQ1
3
2
1
1
1
5
MANATOKAN
LAKE
BF1
1
1
4
BA1
BM1
4
BM1
N
1KM

LAKE: MANATOKAN

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8A1.1	500	Aquatic II	30	1	3 - 2	Hard silt	D	Myriophyllum exalbescens (sparse)
		Aquatic I	50	1	2 - 1.5	Hard silt	D	Potamogeton richardsonii, Chara globularis
		Emergent	50	1	1.5	Soft silt	D	Nuphor variegatum (medium)
		Aquatic I	50	1	1.0 - 0	Hard silt	D	Myriophyllum exalbescens
		Phreatic	150	1	1.5	Silt	D	Scrub; willow, Meadow; sedge
		Upland	150 +	2-5	1.5 +	Silt loam	I	Scrub; willow, Agricultural

PROFILE



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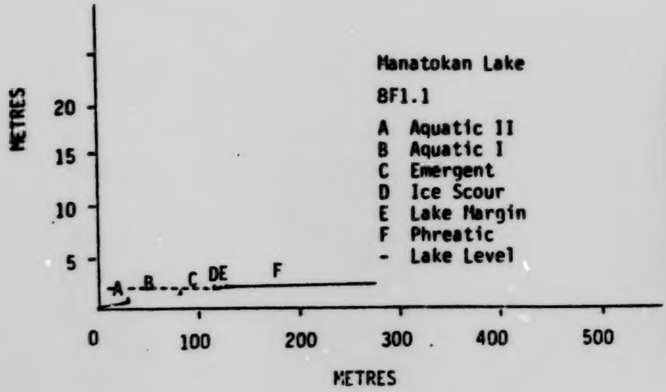
* D - Depressional
I - Inactive Erosional

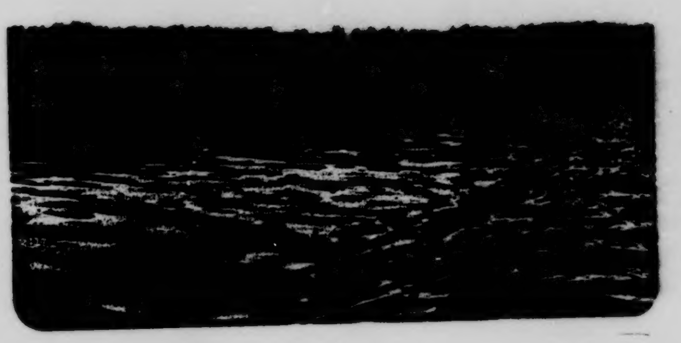
LAKE: MANATOKAN

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8F1.1	700	Aquatic II	30	2	3 - 1.5	Sand	D	Filamentous green algae with Lemna calcata
		Aquatic I	50	2	1.5 - 1	Sand and silt	D	Myriophyllum exalbescens
		Emergent	35	2	1 - .2	Sand	D	Nuphar variegatum
		Ice Scour	5	2	0.2 - 0	Sand	E	No vegetation
		Lake Margin	1	2-5	0.2	Sand beach	D	Sparse vegetation
		Phreatic	150	0-1	1	Sand and organic	D	Scrub; willow

Ecotype 8F1.1. This ecotype occurs along the western shore of Manatokan Lake. It is a depositional landform transported by Osborne Creek to its present location from sandy and silty deposits upstream.

PROFILE





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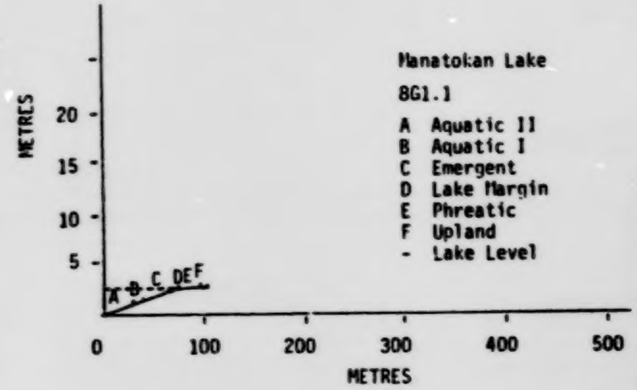
* D - Depressional
E - Erosional

LAKE: MANATOKAN

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8G1.1	1 300	Aquatic II	30	4	3 - 2	Silt	I	Potamogeton praelongis (dense)
		Aquatic I	10	4	2	Silt	I	Myriophyllum exalbescens
		Emergent	30	4	1.5	Silt	I	Nuphar variegatum, Scirpus validus
		Lake Margin	1	0-1	.2	Sand	I	
		Phreatic	20	0-1	1	Silt and sand	I	Scrub; willow
		Upland		0-1	5	Silt and sand	I	Agricultural

Ecotype 8G1.1 Note the flat character of this ecosection.

PROFILE



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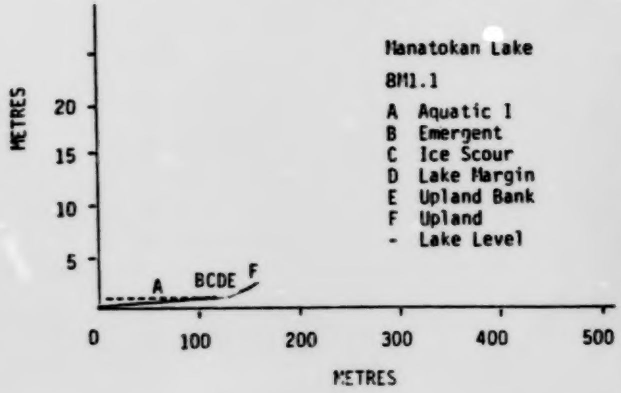
* I - Inactive Erosional

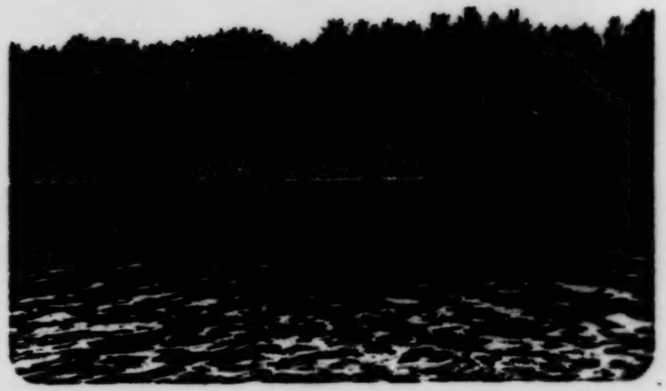
LAKE: MANATOKAN

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8M1.1	1 000	Aquatic I	110	0 - 1	2	Sand	D	Myriophyllum exalbescens (dense)
		Emergent	8	0 - 1	0.5	Sand	D-I	Scirpus (10%)
		Ice Scour	2	0 - 1	0.5	Sand	E	Sparse Chara
		Lake Margin	.5	2 - 5	0.5	Sand and cobbles	I-E	
		Upland Bank	1	5 - 9	2		E	Willow (dense)
		Upland		2 - 5		Sand	I	Open aspen forest

Ecotype 8M1.1. The ecosection is common along the north shore of Manatokan Lake.

PROFILE





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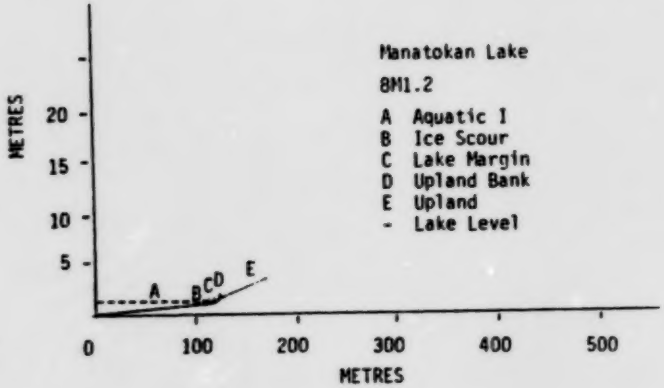
* D - Depressional
E - Erosional
I - Inactive Erosional

LAKE: **MANATOKAN**

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status	Vegetation
8M1.2	300	The ecotype is similar to 8M1.1 but lacks an emergent zone. The upland bank zone is approximately 2 m in local relief. The upland vegetation has been changed to make way for farm buildings.						

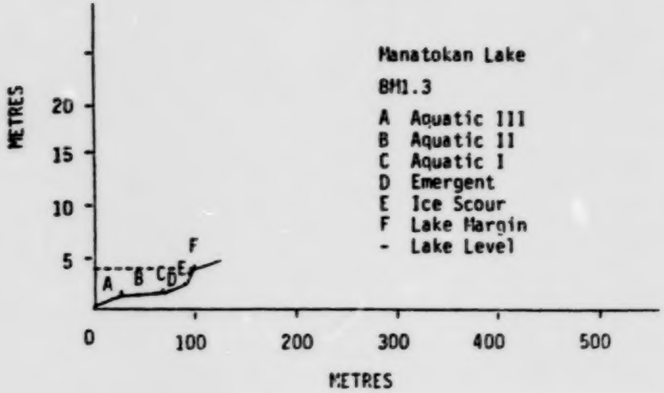
PROFILE



LAKE: MANATOKAN

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8M1.3	600	Aquatic III	30	4	3 - 2	Silt	D	Sparse filamentous green algae
		Aquatic II	40	1	2	Silt	D	Potamogeton praelongis (dense)
		Aquatic I	5	6	1.5	Silt	D	Myriophyllum exalbescens, Potamogeton zosterisformis (dense)
		Emergent	20	4	1.2	Silt	D	Nuphar variegatum (50-70%)
		Ice Scour	5	4	0.2	Silt	E	Not sampled
		Lake Margin	1	30	0.5	Cobbles	I	No vegetation

PROFILE



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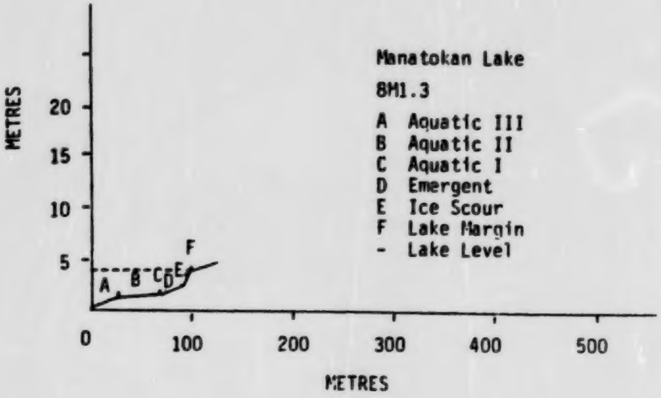
* D - Depressional
E - Erosional
I - Inactive Erosional

LAKE: MANATOKAN

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8M1.3 continued	600	Upland Bank	10	30	0.5 - 2.5	Sandy	I	Willow/fireweed
		Upland		2-5		Sandy loam	I	Closed aspen forest

Ecotype 8M1.3. The ecotype is well sheltered from storm winds which accouts for the large amount of Nuphar variegatum (foreground).

PROFILE



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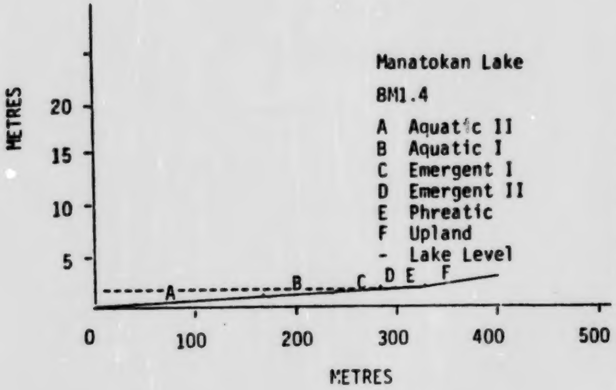
* I - Inactive Erosional

LAKE: MANATOKAN

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8M1.4	6 500	Aquatic II	180-150	1	3 - 2	Hard silt	D	Myriophyllum exalbescens (sparse)
		Aquatic I	100-50	1	2 - 1.5	Hard silt	D	Potamogeton richardsonii, Chara globularis
		Emergent I	100-0	1	1.5 - 2	Hard sand	D	Scirpus
		Emergent II	30-0	1	.4 - 2	Sand	D	Scrub; willow/Phragmites
		Phreatic	0-75	1	.7	Sand	D	Scrub; willow/sedge
		Upland		2-5		Loam	I	Closed mixedwood forest; aspen, spruce

Ecotype 8M1.4. A view of the intersection between Chara globularis of the Aquatic I zone and Scirpus validus of Emergent I.

PROFILE



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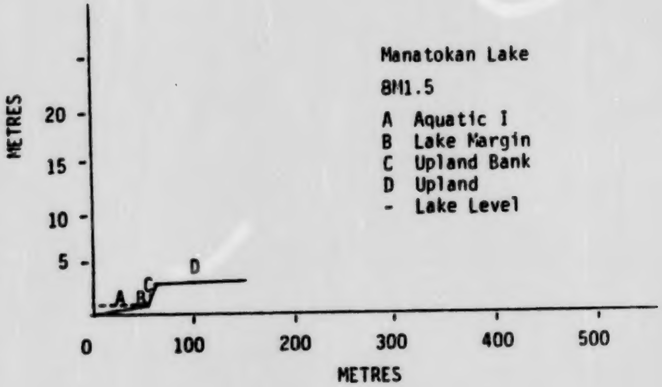
* D - Depressional
I - Inactive Erosional

LAKE: MANATOKAN

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status *	Vegetation
8M1.5	500	Aquatic I	50	2	0 - 2	Hard sand	I	Chara globularis (sparse)
		Lake Margin	10	20	2	Sand	D-E	
		Upland Bank	10 +	20	2 - 4	Sand	I-E	Scrub; balsam poplar
		Upland		0 - 1				Agricultural, campground

PROFILE



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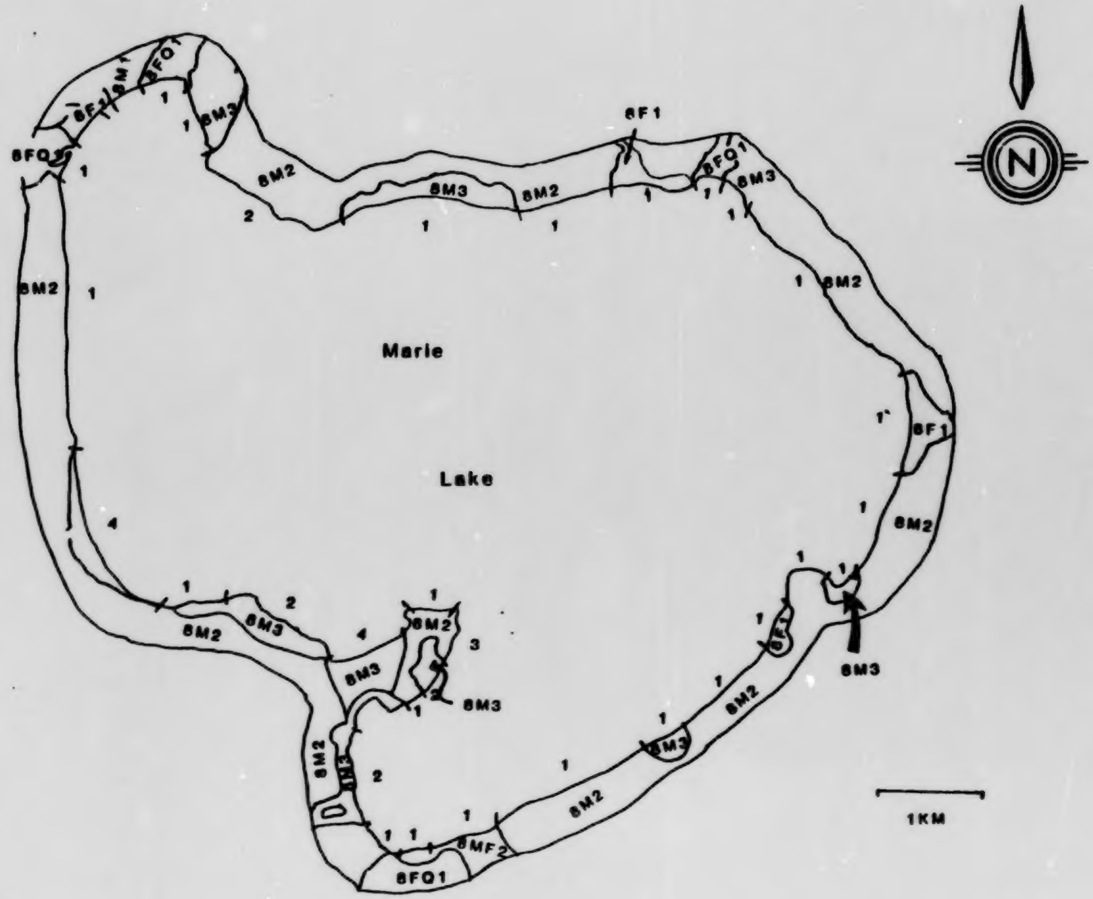
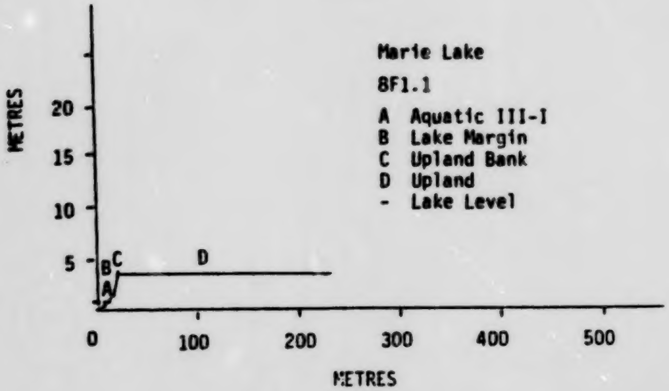
* D - Depressional
E - Erosional
I - Inactive Erosional


Marie
Lake
8F1
8FO1
8M3
8M2
8MF2
8FO1
8M3
1KM
N
1
2
3
4

LAKE: MARIE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8F1.1	1 800	Aquatic III-I		2 - 6		Sand	E	No plants
		Lake Margin	3 - 4	9 -15	1	Sand beach	E-D	
		Upland Bank	2 - 3	71 -45	1	Sand	E	Scrub (sparse)
		Upland	20-300	0 - 1		Sand terrace		Closed and open mixedwood forest; aspen (sparse)

PROFILE



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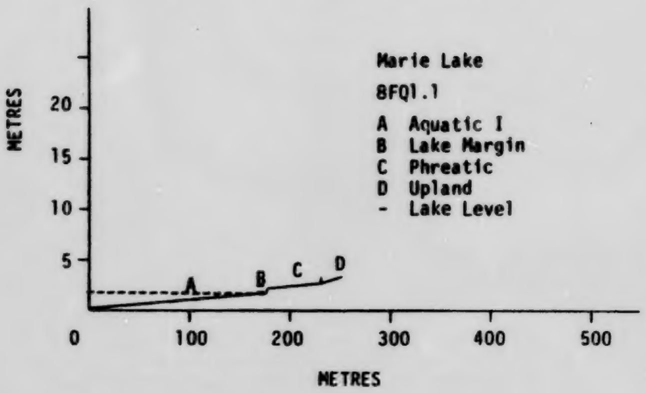
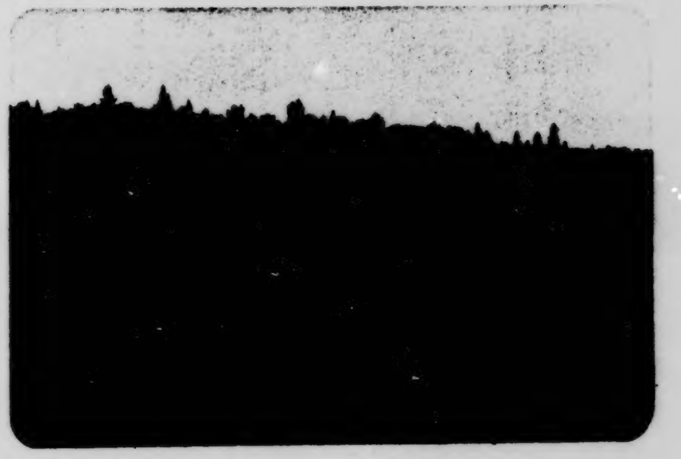
*. E - Erosional
D - Depositional

LAKE: MARIE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8FQ1.1	1 000	Aquatic I	50-300	0-1	1-0	Hard sand	D	Chara globularis (sparse)
		Lake Margin	1-2	16-30	.5	Sand beach with some cobbles and boulders	D	
		Phreatic	10-100	0-1	1	Loamy till mixed with sand		Scrub; willow
		Upland		2-5		Loamy till		Closed mixedwood forest

PROFILE





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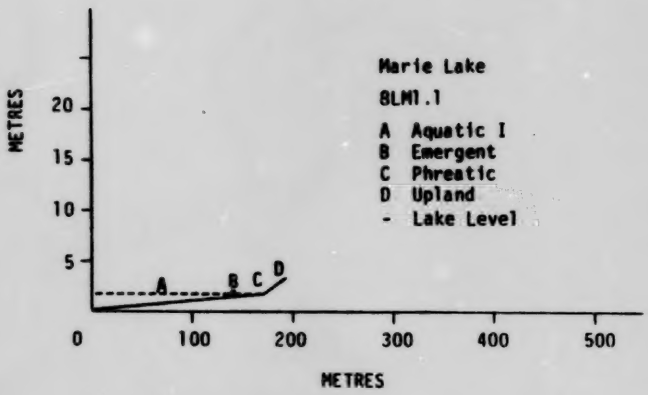
* D - Depositional

LAKE: MARIE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8LM1.1	500	Aquatic I	140	1	1-.3	Silt	D	Potamogeton filformis, Potamogeton zosterisformis (medium)
		Emergent	3	1	0-.3	Silt	D	Typha latifolia, Calla palustris
		Phreatic	20-40	0-1		Silt	D	Scrub; willow, Calamagrostis spp.
		Upland		6-9		Loamy till		Closed mixedwood forest; aspen

PROFILE



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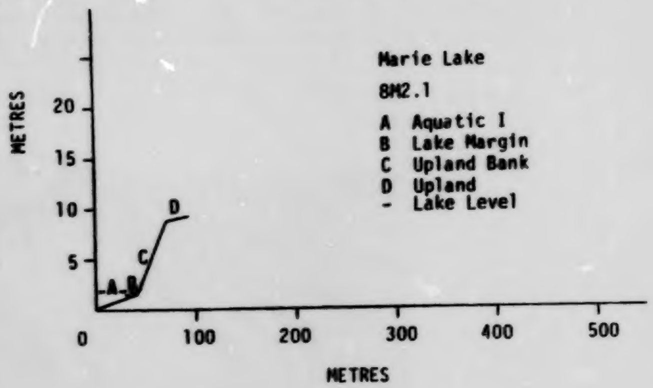
[*] D - Depositional

LAKE: MARIE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8M2.1	10 000	Aquatic I	40	4	2-0	Hard sand	I	Potamogeton zosteriformis (sparse)
		Lake Margin	1	16-30		Cobbles & boulders	I	
		Upland Bank	30	16-30	12	Sandy loam till	E	Closed mixedwood forest; aspen, spruce
		Upland		2-5		Loamy till	I	Closed mixedwood forest; aspen, spruce

PROFILE



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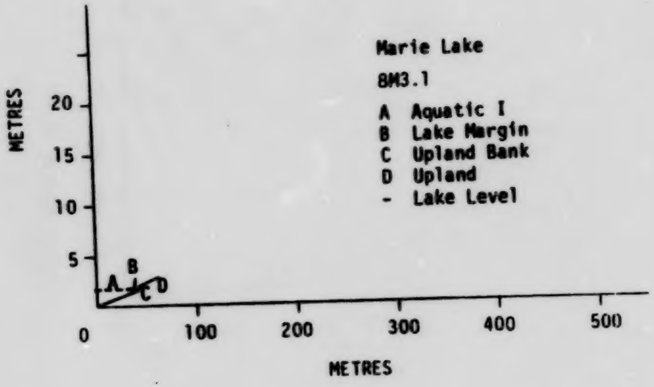
* I - Inactive Erosional
E - Erosional

LAKE: MARIE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8M3.1	2 000	Aquatic I	40	4	2	Hard sand	I	Potamogeton zosteriformis (sparse)
		Lake Margin	1	16-30	0.3	Cobbles & boulders	I	
		Upland Bank	1 - 3	16-30	1-2	Loamy till	E	Scrub; willow
		Upland		2-5		Loamy till	I	Closed mixedwood forest; aspen, spruce

PROFILE



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* I - Inactive Erosional
E - Erosional

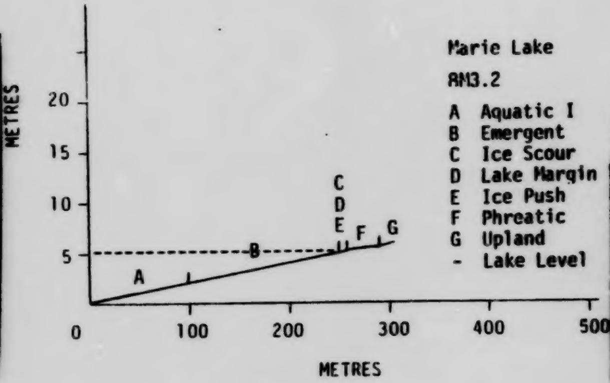
LAKE: MARIE LAKE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status *	Vegetation
8M3.2	2 000	Aquatic I.	100	2	3 - 1.5	Soft silt	D	Potamogeton natans (medium)
		Emergent I	0-300	2	1.5-.3	Sand	D	Scirpus validus, Myriophylum exalbescens
		Ice Scour	5	2	0.3	Sand and silt	D	
		Lake Margin	1-2	6-9	0.3	Sand and cobbles	I	
		Ice Push	1	1-2		Sandy loam with boulders	E	
		Phreatic	30	0-1	0.3-1	Sandy loam	I	Scrub; willow
		Upland		2-5		Sandy loam till	I	Closed mixedwood forest; aspen

Shoreline Type 8M3.2(a): Note Potamogeton natans in the foreground, the only noted occurrence of this usually common species in the survey.

Shoreline Type 8M3.2(b): This large Scirpus bed is discontinuous in this type.

PROFILE



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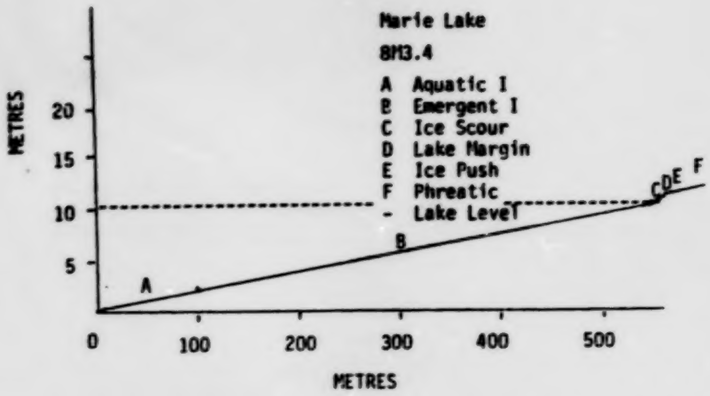
* D - Depositional
I - Inactive Erosional
E - Erosional

LAKE: MARIE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status	Vegetation
8M3.4	500	Similar to 8M3.2 with a large (600 m) Emergent Zone dominated by sparse Scirpus.						

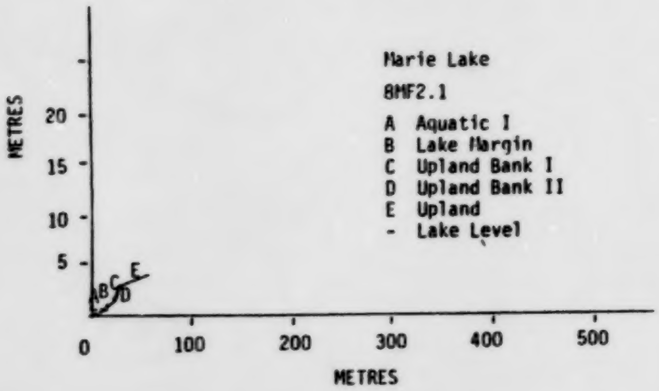
PROFILE



LAKE: MARIE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8MF2.1	600	Aquatic I		5	2 - 0	Hard sand	E	
		Lake Margin	2	6-9	0.5	Cobbles & boulders	I	
		Upland Bank I	5	6-9	0.5	Cobbles & boulders	I	Scrub; willow
		Upland Bank II	10	31-45	0.5-4	Loam till	E	Closed mixedwood forest; aspen, spruce
		Upland		2-5		Loamy till	I	Closed mixedwood forest; aspen

PROFILE



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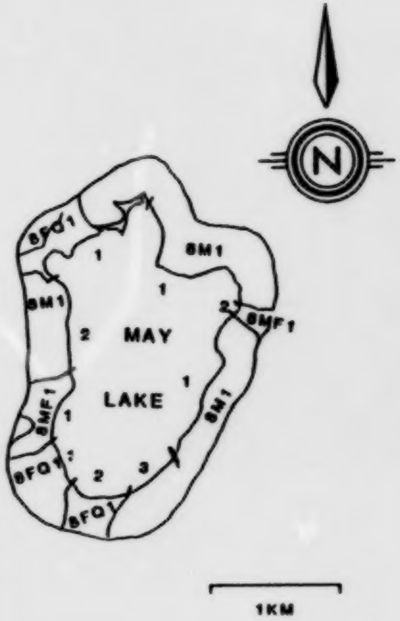
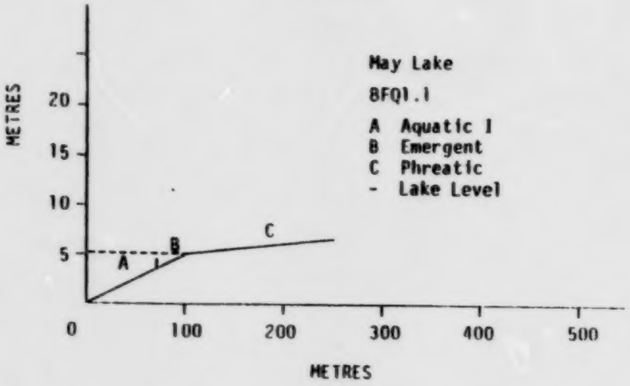
* E - Erosional
I - Inactive Erosional


N
BFO1
BM1
1
1
2
MAY
LAKE
BM1
2
BMF1
1
BM1
BMF1
1
BFO1
2
3
BFO1
1KM

LAKE: MAY[1]

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status	Vegetation
BFQ1.1	2 400	Aquatic I	70	3 - 6	1.5 - 2	Sandy	D - E	Potamogeton (sparse)
		Emergent	30	3 - 6	0.5	Sandy	D	Scirpus validus
		Phreatic	100-200	0 - 1		Sandy & organic	D	Scrub; willow, birch

PROFILE



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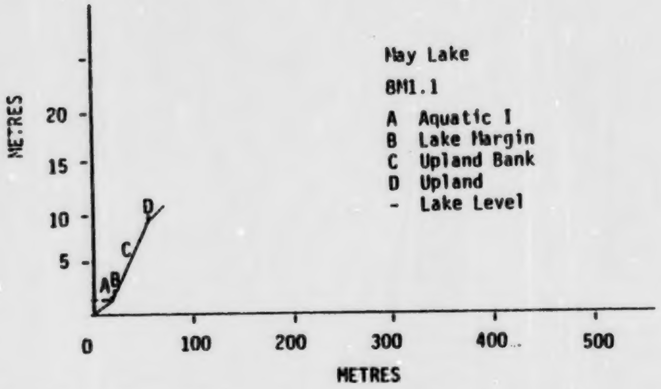
[1] These shoreline types have been interpreted from air photos only. They have not been ground-truthed.

* D - Depressional
E - Erosional

LAKE: MAY[1]

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8M1.1	3 000	Aquatic I	20	6 - 9	2	Sand	E	Sparse Potamogeton
		Lake Margin	1	16-30	0.5	Cobbles & sand	I	
		Upland Bank	30-45	16-30	10-15	Sandy loam till	E	Closed mixedwood forest; aspen, spruce
		Upland		10-15		Sandy loam till	I	Closed mixedwood forest; aspen, spruce

PROFILE



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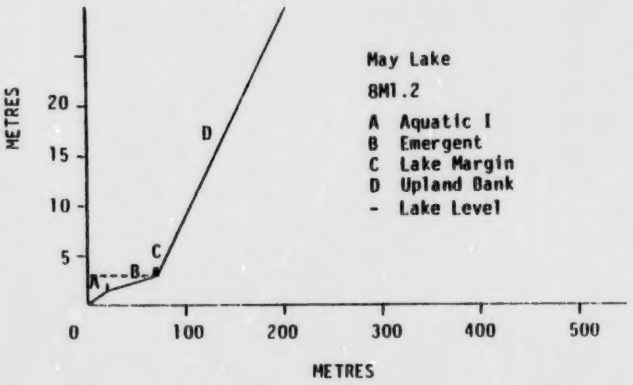
[1] These shoreline types have been interpreted from air photos only. They have not been ground-truthed.

* E - Erosional
I - Inactive Erosional

LAKE: MAY[1]

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status *	Vegetation
8M1.2	1 000	Aquatic I	20	6 - 9	3	Sand	E	Sparse Potamogeton
		Emergent	50	2 - 5	0-1	Sandy	I	Scirpus validus, Nuphar variegatum
		Lake Margin	1	16-30	0.5	Cobbles	I	
		Upland Bank	130	16-30	5	Sandy loam till	E	Closed mixedwood forest; aspen, spruce
		Upland						Closed mixedwood forest; aspen, spruce

PROFILE



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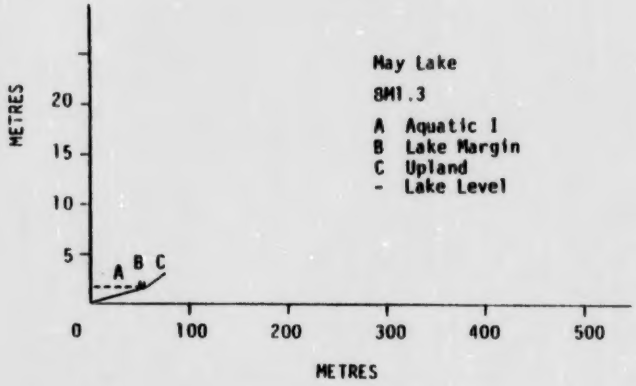
[1] These shoreline types have been interpreted from air photos only. They have not been ground-truthed.

* E - Erosional
I - Inactive Erosional

LAKE: MAY[1]

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8M1.3	500	Aquatic I	50	2 - 5	2	Sand	I	Myriophylum exalbescens, Potamogeton spp.
		Lake Margin	5	2 - 5	15	Sand	D	
		Upland		6 - 9		Sandy loam	I	Closed mixedwood forest; aspen, spruce

PROFILE



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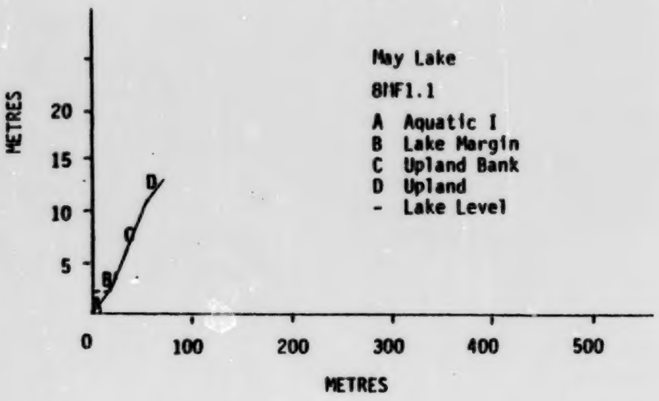
[1] These shoreline types have been interpreted from air photos only. They have not been ground-truthed.

* I - Inactive Erosional
D - Depressional

LAKE: MAY[1]

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status	Vegetation
8MF1.1	700	Similar to 8M1.1						

PROFILE



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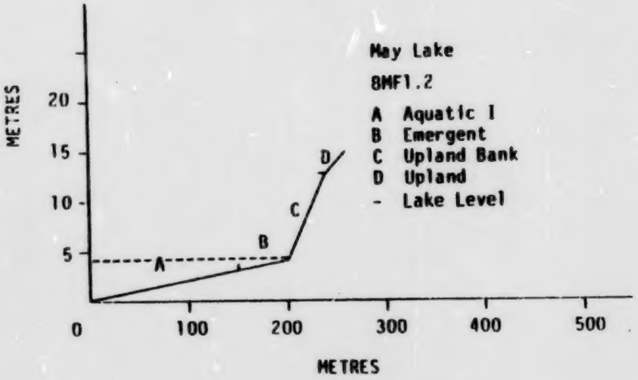
[1] These shoreline types have been interpreted from air photos only. They have not been ground-truthed.

LAKE: MAY[1]

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status *	Vegetation
8MF1.2	45	Aquatic I	150	1 - 2	0.5-3	Sandy	D	Myriophylum exalbescens
		Emergent	50	1 - 2	0.5	Sandy	D	Scirpus validus, Nuphar variegatum
		Upland Bank	30-45	16-30	10 - 15	Sandy loam till	E	Closed mixedwood forest; aspen, spruce
		Upland		10-15		Sandy loam till	I	Closed mixedwood forest; aspen, spruce

PROFILE



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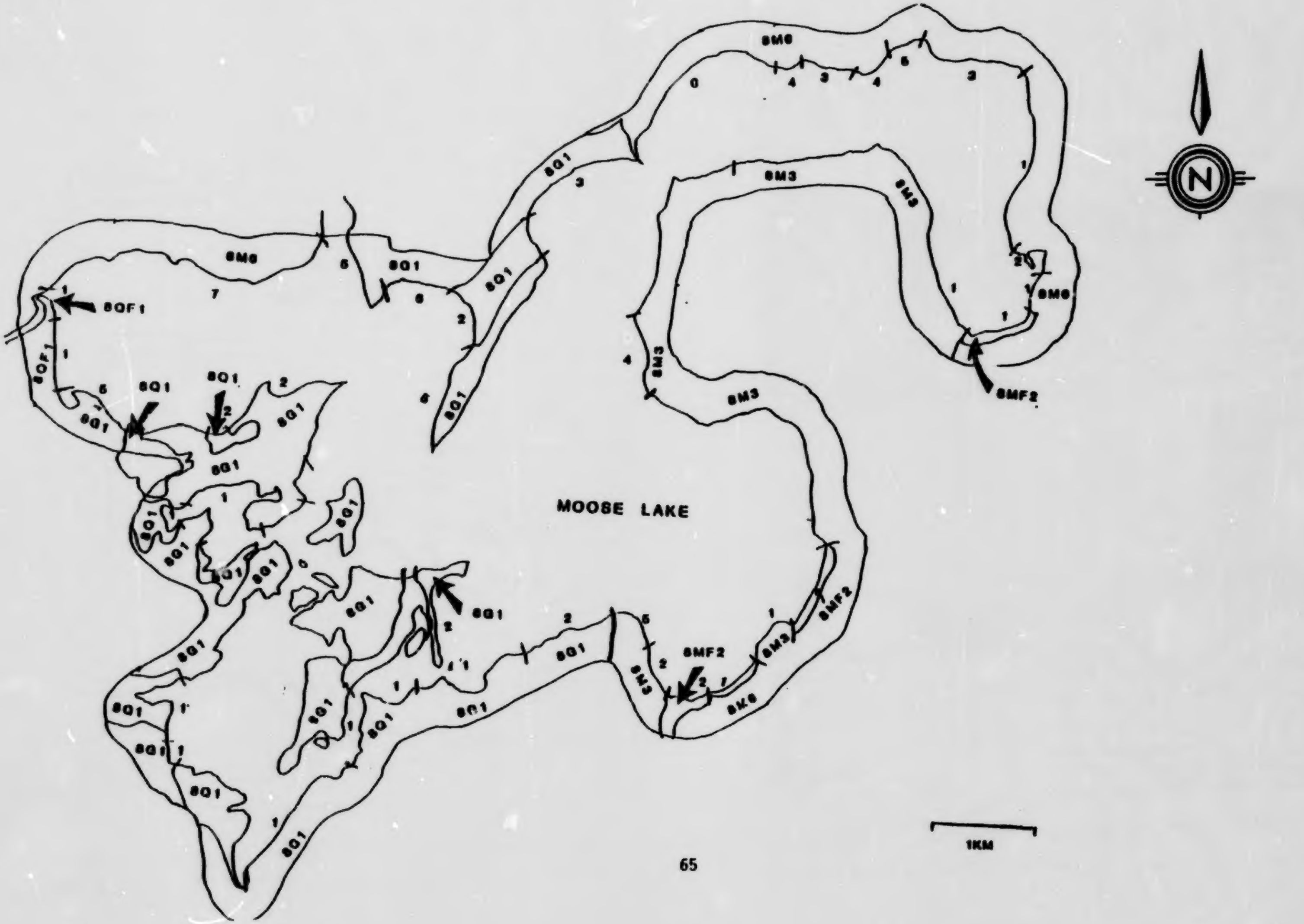
[1] These shoreline types have been interpreted from air photos only. They have not been ground-truthed.

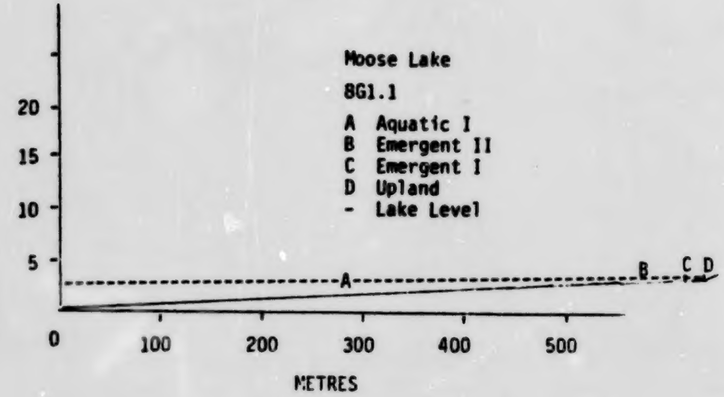
* D - Depositional
E - Erosional
I - Inactive Erosional


MOOSE LAKE
N
1KM
SM6
SM3
SMF2
SG1
SOF1
SK6

LAKE: MOOSE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8G1.1	19 300	Aquatic I	1 000	0-1	2	Silty sandy, and organic bottom	D	Myriophylum exalbescens, Ceratophylum, filamentous green algae, Chara globularis
		Emergent II	100-300	0-1	1-1.5	Sandy	D	Scirpus validus
		Emergent I	10	0-1	0.2	Sandy	D	Typha latifolia, Carex aquatilis
		Upland		1-5		Sandy glacio-fluvial outwash	E	Closed mixedwood forest; aspen/rose/Timothy

PROFILE



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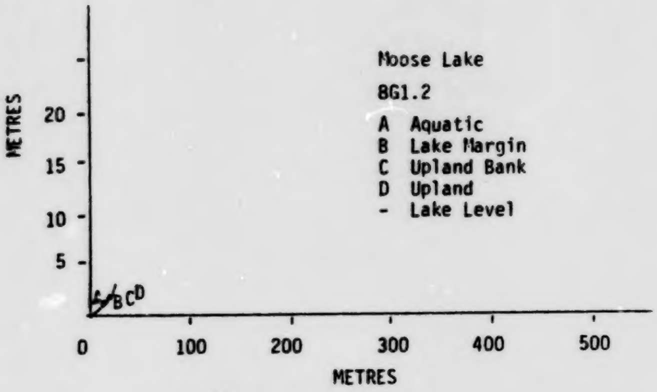
* D - Depositional
E - Erosional

LAKE: MOOSE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8G1.2	4 000	Aquatic	20	9	2	Sand	E	Chara globularis (sparse)
		Lake Margin	1	16-30	0.3	Sandy beach	E	
		Upland Bank	2-3	31-45	1	Gravelly sand	E	
		Upland				Gravelly sand terrace		Closed mixedwood forest; aspen

PROFILE



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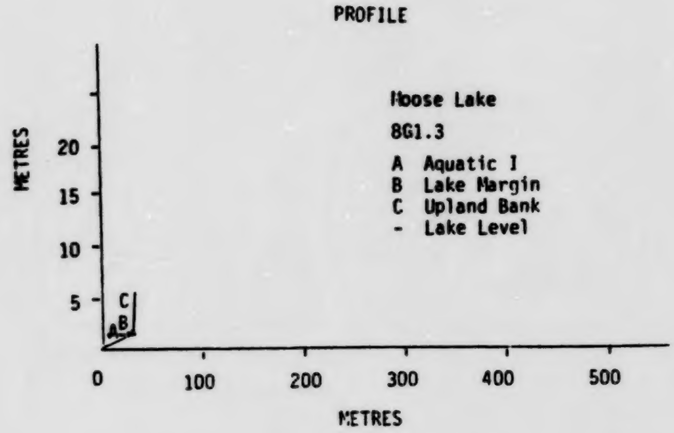
* E - Erosional

LAKE: MOOSE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8G1.3	1 400	Aquatic I	30	5	1.5	Sand	D	Potamogeton zosteriformis, Myriophylum exalbescens (sparse) Filamentous green algae (dense)
		Lake Margin	3		0.5	Sand	E	
		Upland Bank		96-100		Sandy	E	Open mixedwood forest; aspen



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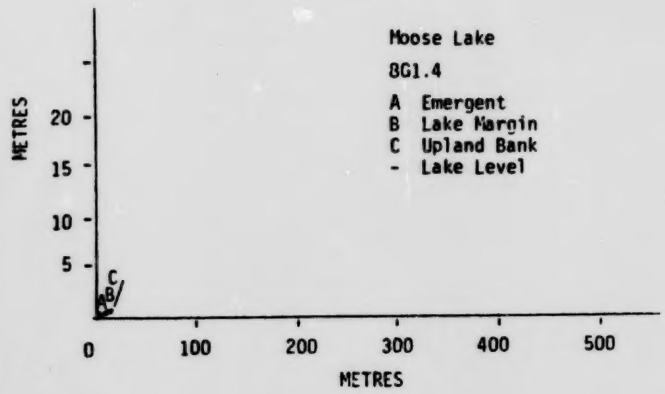
* D - Depositional
E - Erosional

LAKE: MOOSE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8G1.4	3 600	Emergent	10	4	1	Silt and sand	E-D	Scirpus validus (very sparse)
		Lake Margin	3	2-5	0.1	Sand beach	E-D	
		Upland Bank		31-45	1-8	Sand	E	Open and closed mixedwood forest; aspen

PROFILE



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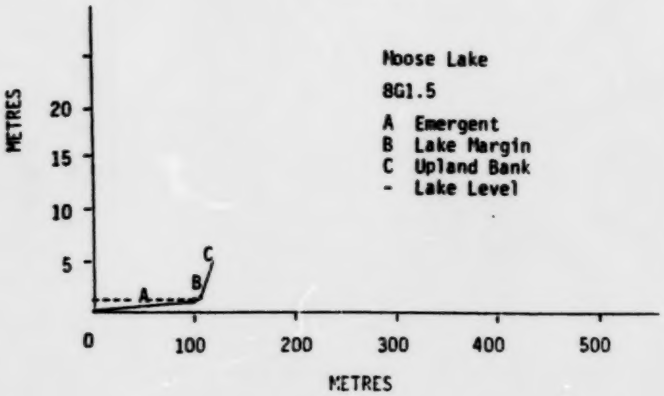
* E - Erosional
D - Depositional

LAKE: MOOSE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8G1.5	4 000	Emergent	100	1 - 2	1.5	Sand	D	Scirpus validus
		Lake Margin	3	2 - 5	0.1	Logs and sand	D	
		Upland Bank		31 - 100		Sand	E	Closed mixedwood forest; spruce, aspen

PROFILE

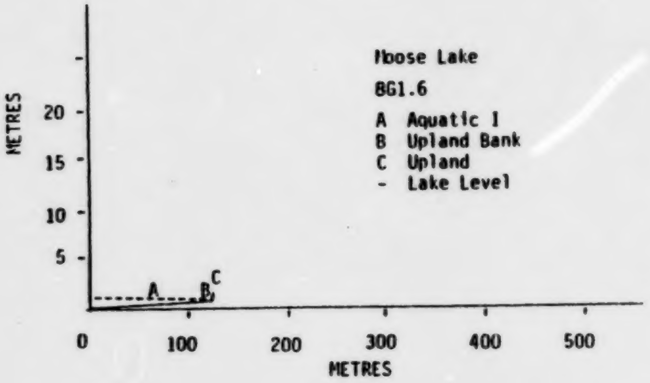


* D - Depositional
E - Erosional

LAKE: MOOSE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8G1.6	600	Aquatic I	120	1	1.5	Silt	D	Ceratophylum spp., Myriophylum exalbescens, filamentous green algae (dense)
		Upland Bank	2	46-100	1	Sandy terrace bank	E	Scrub and fireweed
		Upland				Sandy terrace	I	Open aspen forest

PROFILE



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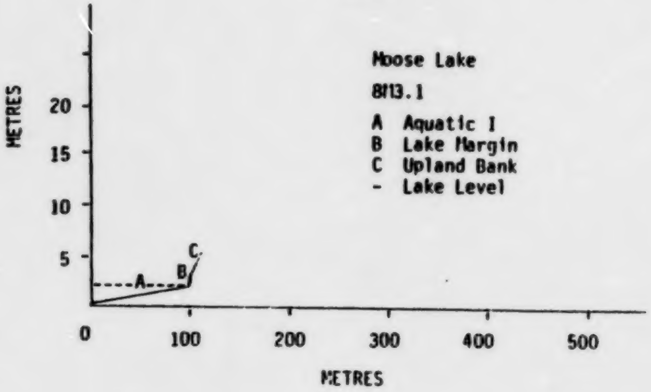
* D - Depositional
E - Erosional
I - Inactive Erosional

LAKE: MOOSE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8M13.1	7 500	Aquatic I	100	2	2	Silt	D	Ceratophylum spp., Myriophylum exalbescens (dense)
		Lake Margin	1-2	16-30	3	Cobbles & boulders	I	
		Upland Bank		10-30	2-10			Closed mixedwood forest; aspen

PROFILE



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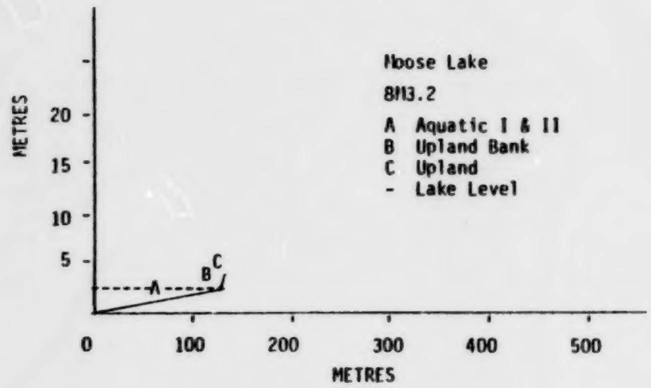
* D - Depositional
I - Inactive Erosional

LAKE: MOOSE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status	Vegetation
8M3.2	400	Aquatic I & II	130	2	3	Sand and silt		Ceratophylum spp.,filamentous green algae (sparse)
		Upland Bank	2	46-100	2	Sandy loam till		Scrub; willow
		Upland				Sandy loam		Closed mixedwood forest; aspen/willow-dogwood

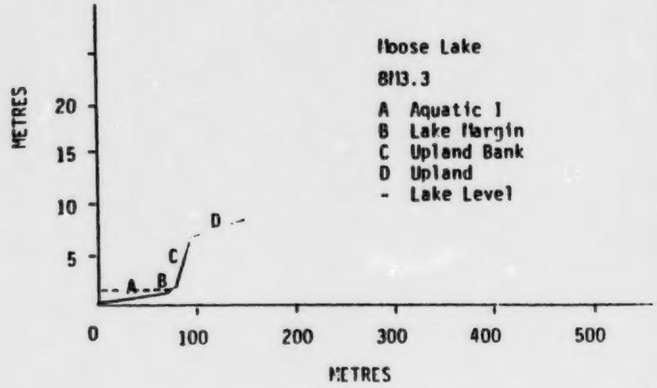
PROFILE



LAKE: MOOSE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status *	Vegetation
8M3.3	2 000	Aquatic I	70	2	1.5	Sand	E-D	Chara globularis (sparse)
		Lake Margin	2	10	0.2	Sandy beach	D	
		Upland Bank	30	31-45	10-15	Clay loamy till		Closed mixedwood forest; aspen
		Upland		2-5		Clay loamy till		Closed mixedwood forest; aspen

PROFILE



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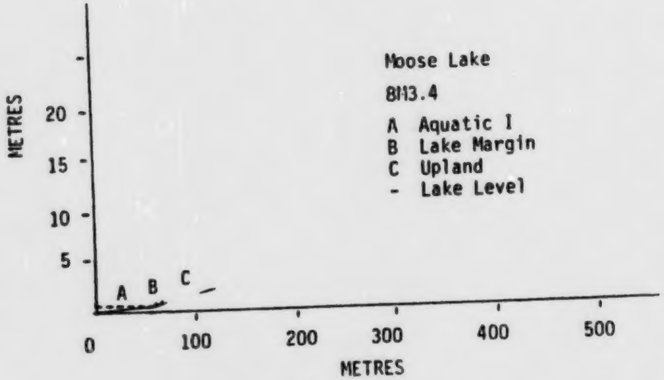
* E - Erosional
D - Depositional

LAKE: MOOSE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8M3.4	800	Aquatic I	60	1	1	Sand	D-E	Chara globularis (very sparse)
		Lake Margin	10	2-5	0.5	Sandy beach	D	
		Upland		2-5		Sand terrace	D	Closed mixedwood forest; aspen

PROFILE



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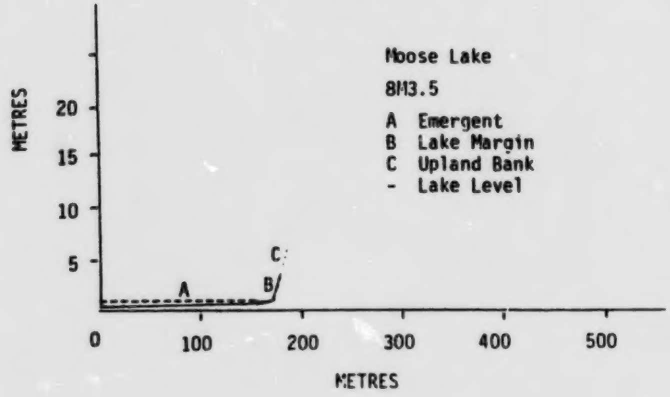
* D - Depositional
E - Erosional

LAKE: MOOSE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8M3.5	600	Emergent	160	0-1	1	Sandy	D	Scirpus validus
		Lake Margin	2	2-5	0.3	Sandy with cobbles	D-E	
		Upland Bank		31-45				Aspen/willow

PROFILE



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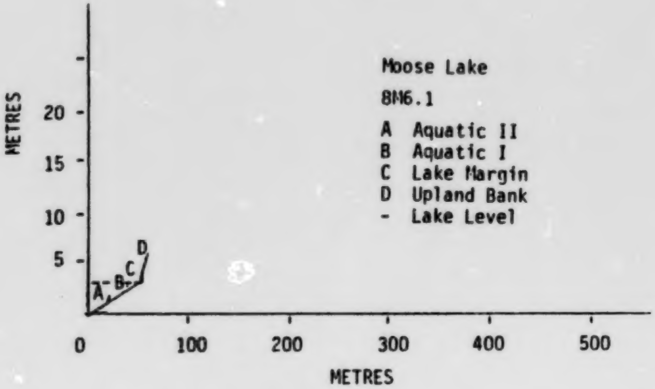
* D - Depositional
E - Erosional

LAKE: MOOSE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8M6.1	450	Aquatic II	20	8	2	Sand	E	Ceratophyllum (sparse)
		Aquatic I	30	8	2	Sand	E	Chara globularis (sparse)
		Lake Margin	0.3	100	0.3	Cobbles and boulders	I	
		Upland Bank		46-100	8-12	Clay loam till	E	Closed mixedwood forest; aspen

PROFILE



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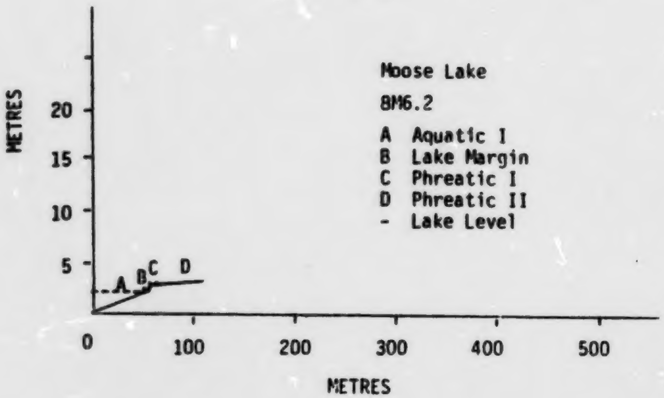
* E - Erosional
I - Inactive Erosional

LAKE: MOOSE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status	Vegetation
8M6.2	500	Aquatic I	50	1-5	2	Sand and silt		Ceratophylum spp. Potamogeton filformis (sparse to dense)
		Lake Margin	0.5-1	20	0.2	Sand		
		Phreatic I	5	0-1		Sand		Typha latifolia, Hordeum jubatum
		Phreatic II	50	0-1	0.5			Scrub; willow

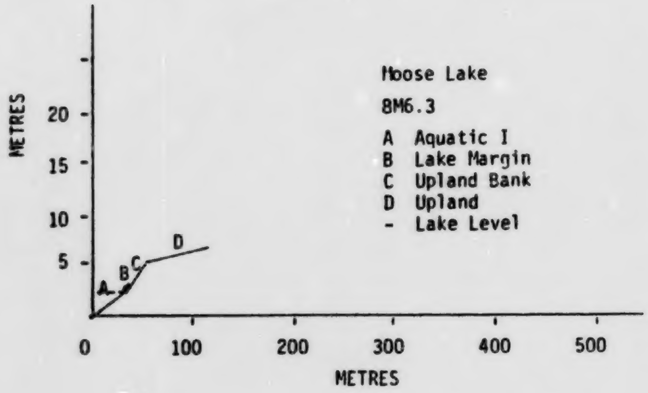
PROFILE



LAKE: MOOSE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8M6.3	1 600	Aquatic I	35	6-9	2	Sand (hard)	E	Ceratophylum spp. (sparse-medium)
		Lake Margin	1	46-100	0.5	Cobbles & boulders	I	
		Upland Bank	30	31-45	1-5	Clay loam till	E	Closed mixedwood forest; aspen
		Upland		2-5		Clay loam till		

PROFILE



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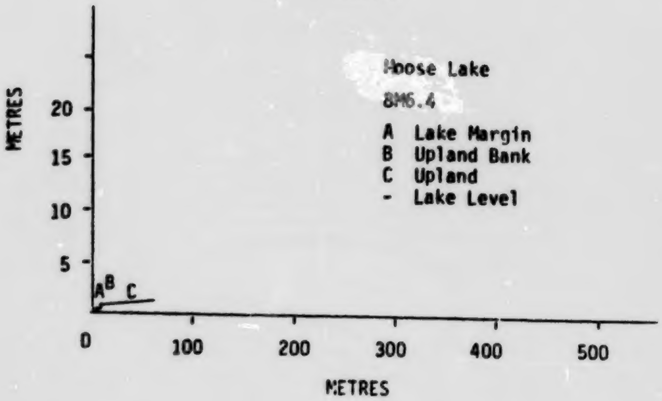
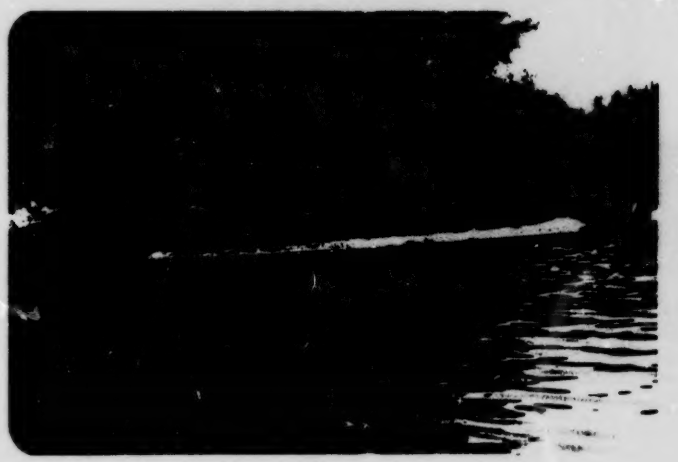
* E - Erosional
I - Inactive Erosional

LAKE: MOOSE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8M6.4	300	Lake Margin	2-5	2-5	0.2	Sandy beach	E-D	
		Upland Bank	1	46-100	1	Sandy terrace	E	Scrub
		Upland		0-5		Sandy terrace	I-E	Open mixedwood forest; spruce, aspen/willow, dogwood

PROFILE





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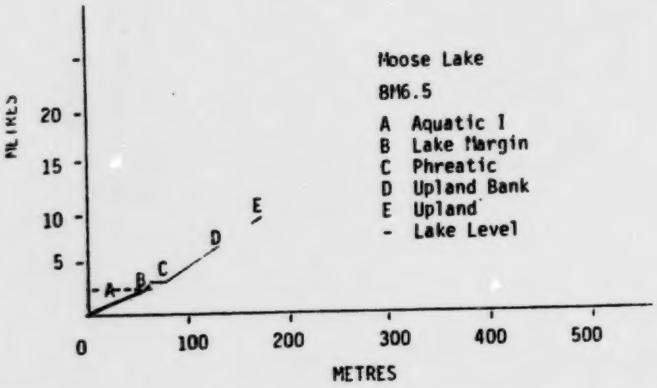
* E - Erosional
D - Depositional
I - Inactive Erosional

LAKE: MOOSE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8M6.5	200	Aquatic I	60	4-6	2	Sand	E-I	Filamentous green algae, Myriophylum exalbescens (sparse)
		Lake Margin	1	16-20	0.2	Sand	D	
		Phreatic	2-5	0-1	0.1	Sand	D	Calamagrostis inexpansa
		Upland Bank		6-9	1			Grasses
		Upland		6-9				Disturbed

PROFILE



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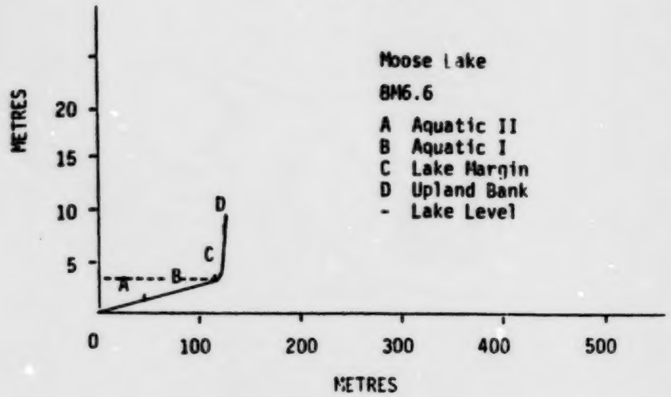
* E - Erosional
I - Inactive Erosional
D - Depositional

LAKE: MOOSE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8M6.6	2 400	Aquatic II	50	3	2	Sand & silt	D	Filamentous green algae (sparse)
		Aquatic I	70	3	2	Sand	D	Myriophylum exalbescens, Ceratophylum spp.,filamentous green algae (dense)
		Lake Margin	1	16-30	0-0.3	Logs and sparse boulders	D-E	
		Upland Bank		41-100	1-5	Clay loam till	E	Closed and open mixedwood forest; aspen, spruce

PROFILE



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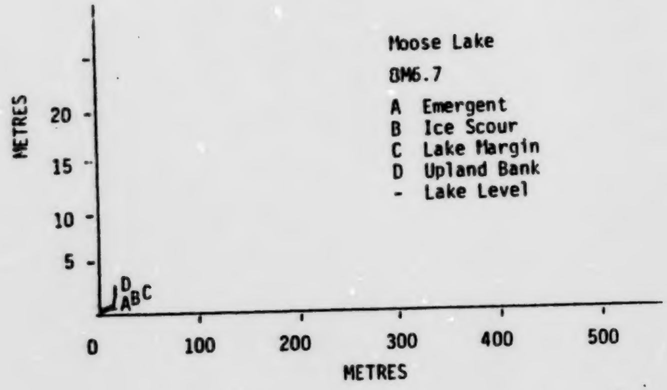
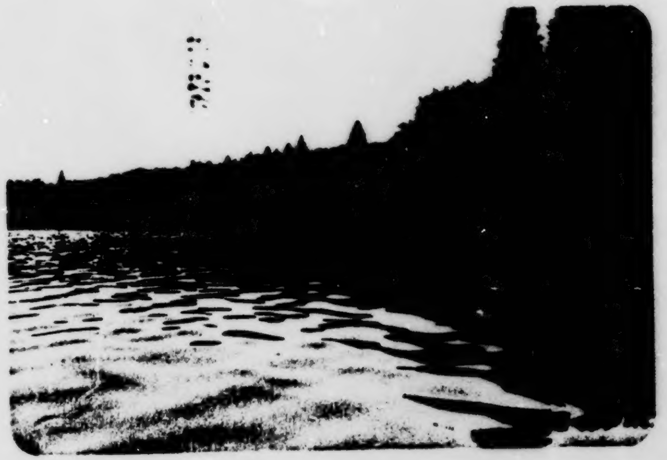
* D - Depositional
E - Erosional

LAKE: MOOSE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status*	Vegetation
8M6.7	3 500	Emergent	1 - 8	5	1 - 1.5	Sand	I-E	Scirpus validus
		Ice Scour	1 - 2	5	0.4	Gravels & cobbles		Chara globularis (sparse)
		Lake Margin	1	46-100	0.5	Cobbles & boulders		
		Upland Bank	2	100 +	1.5 - 2	Clay loam till		Open mixedwood forest; balsam poplar/willow, wolf willow

PROFILE





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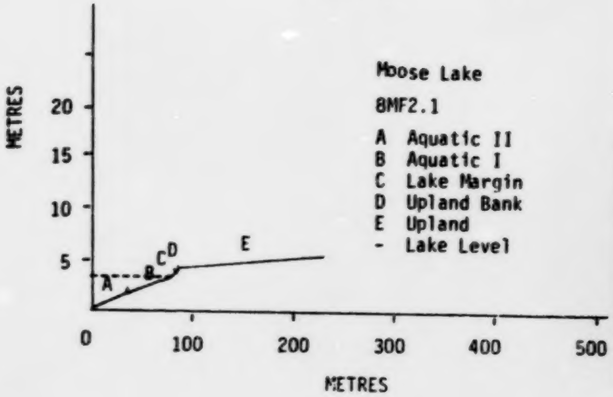
* I - Inactive Erosional
E - Erosional

LAKE: MOOSE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status *	Vegetation
8MF2.1	500	Aquatic II	35	5	2	Silty & sandy	E-D	Filamentous green algae (sparse)
		Aquatic I	50	4-5	2	Silty & sandy		Filamentous green algae (dense), Potamogeton filformis, Myriophylum exalbescens (sparse)
		Lake Margin	2	6-15	0.3	Sandy beach		
		Upland Bank	1	30-45	1	Sand & cobbles	E	Open mixedwood forest; balsam poplar
		Upland		2-5				Open mixedwood forest; balsam poplar

PROFILE



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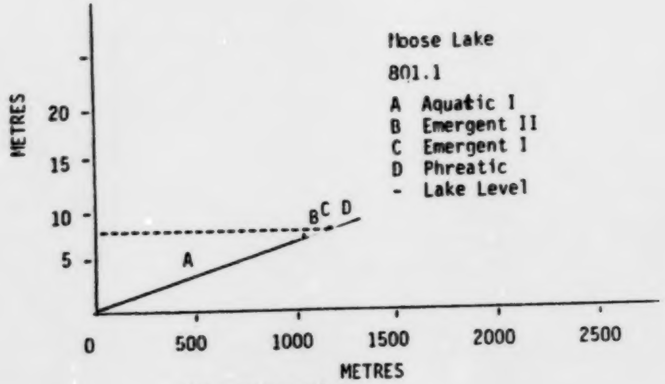
* E - Erosional
D - Depositional

LAKE: MOOSE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8Q1.1	2 800	Aquatic I	1 000	0 - 1	2	Silt, sandy and organic bottom	D	Myriophylum exalbescens, Ceratophylum spp., filamentous green algae, Chara globularis (dense)
		Emergent II	100-300	0 - 1	1 - 1.5	Sandy	D	Scirpus validus
		Emergent I	10-50	0 - 1	0.2	Sand	D	Typha latifolia, Carex aquatilis
		Phreatic	60-300	0 - 1		Sand and clay glacio-fluvial outwash		Scrub; willow, birch, sedge

PROFILE



*NB note scale

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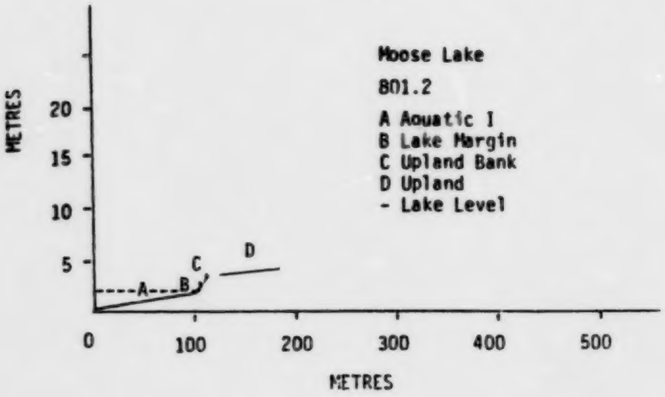
* D - Depositional

LAKE: MOOSE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status	Vegetation
8Q1.2	800	Aquatic I	100	2	2	Silt and sand	D	Ceratophylum spp., Potamogeton zosterisformis (sparse)
		Lake Margin	2		0.2	Sand beach	D	
		Upland Bank	2	16-30	0.5	Sand	E	Calamagrostis expansa
		Upland		0-1		Sand		Open mixedwood forest; pine, aspen/ rose/bearberry/blueberry

PROFILE



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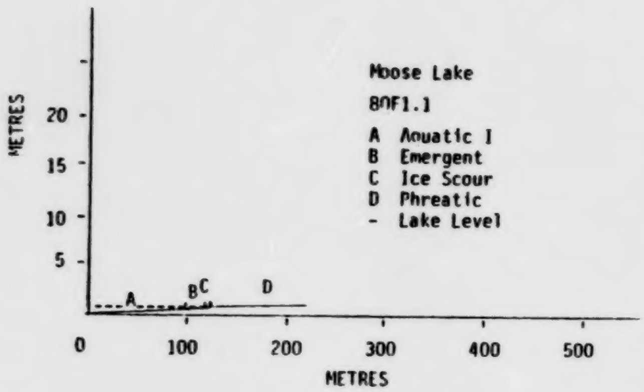
* D - Depositional
E - Erosional

LAKE: MOOSE

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
80F1.1	200	Aquatic I	100	1	1.3	Sand	D	Filamentous green algae (medium)
		Emergent	20	1	1	Sand	D	Scirpus validus
		Ice Scour	2	5	1	Sand	D	
		Phreatic		0-1				Scrub; willow, birch

PROFILE



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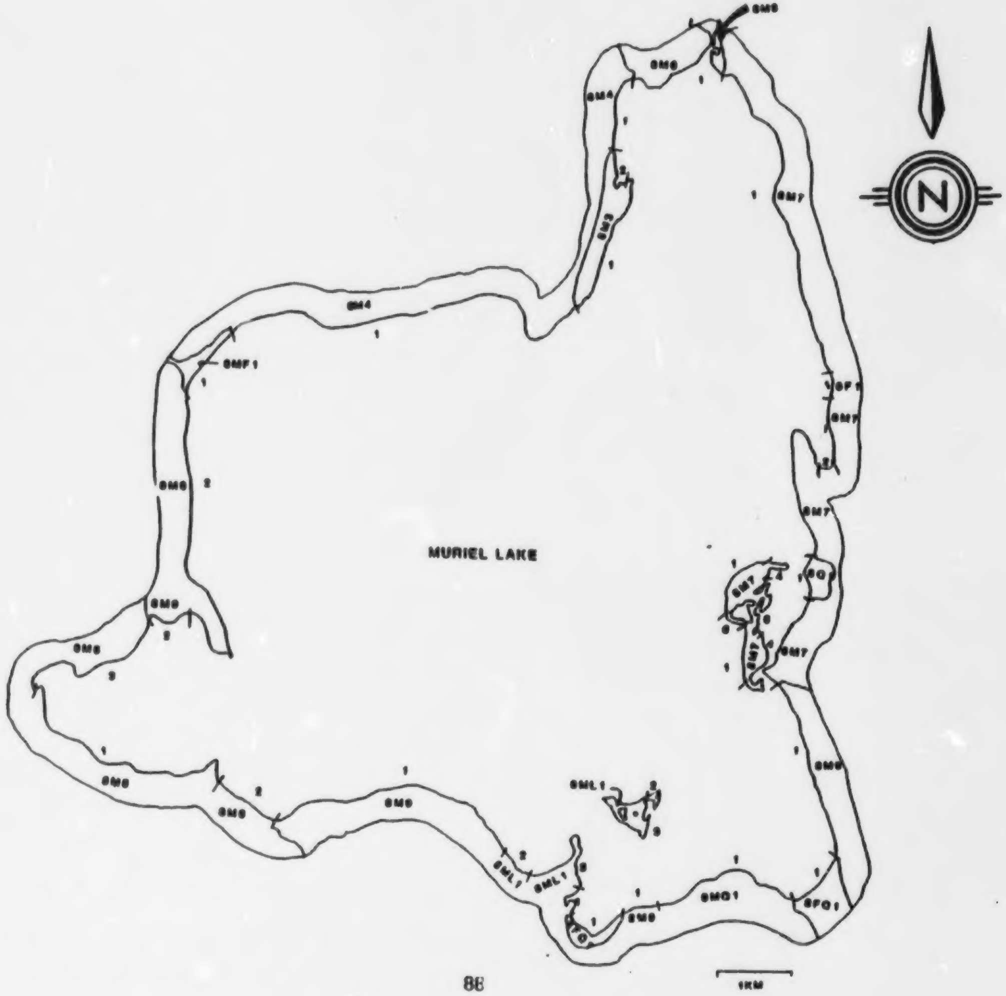
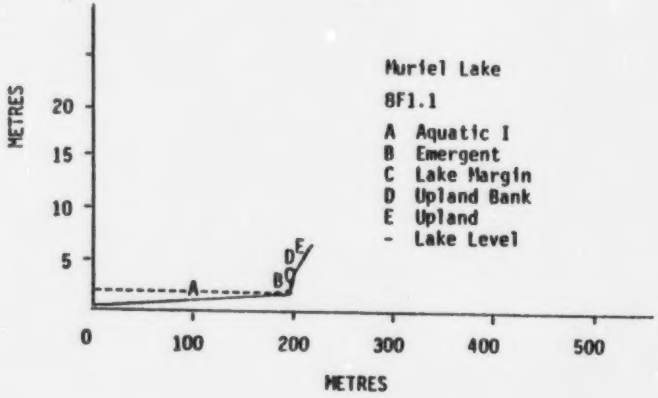
* D - Depositional


MURIEL LAKE
N
SM6
SM4
SM3
SM7
SF1
SMF1
SM9
SML1
SMO1
SFO1
1KM

LAKE: MURIEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status	Vegetation
8F1.1	400	Similar to 8M7.1 except:						
		Upland		16-30		Fluvial sands and gravel		Closed mixedwood forest; Aspen

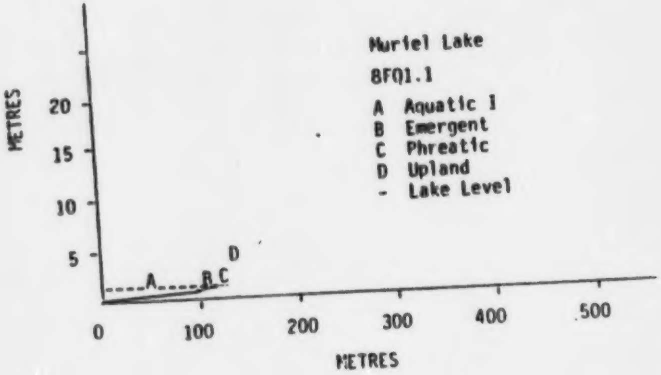
PROFILE



LAKE: MURIEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8FQ1.1	600	Aquatic II-I	120	2	3	Sandy	D-E	Potamogeton pectinatus, Ceratophylum (medium)
		Lake Margin	10	2-5	0.5	Sandy beach	I-D	Closed mixedwood forest; pine
		Upland		0-1	0.5	Sandy terrace		

PROFILE



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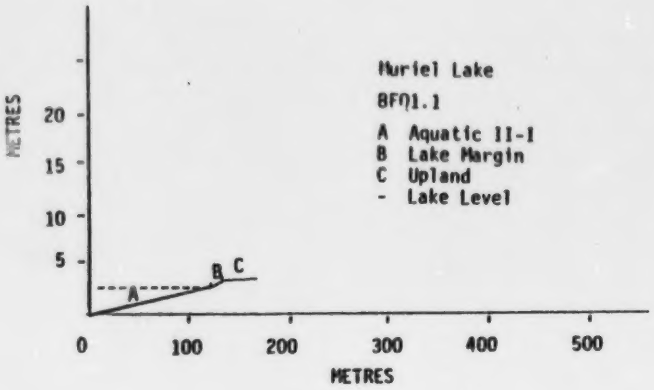
* D - Depositional
E - Erosional
I - Inactive Erosional

LAKE: MURIEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status *	Vegetation
B13.1	2 000	Aquatic I	45	3	1	Sand	D	Potamogeton pectinatus
		Emergent	65	3	1.5	Hard sand	D-E	Scirpus validus (sparse)
		Lake Margin	1-2	16-30	0.2	Cobble		
		Upland Bank		16-30	1			Scrub; willow, balsam poplar
		Upland		10-15				Closed mixedwood forest

PROFILE



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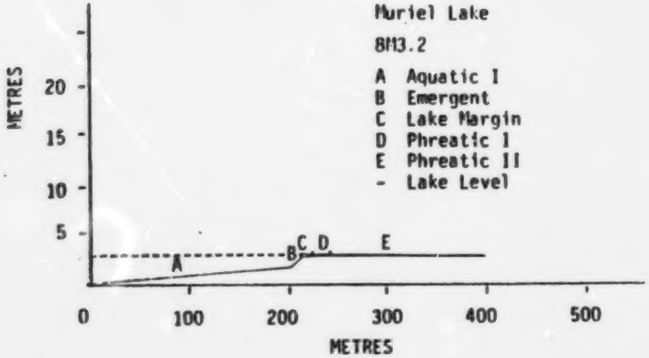
* D - Depositional
E - Erosional

LAKE: MURIEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
BM3.2	700	Aquatic I	200	1	0.75	Silt	D	Potamogeton pectinatus, Utricularia vulgaris (dense)
		Emergent		5	0.5	Silt	D	Typha latifolia
		Lake Margin	5	1	0.2	Sand	E	
		Phreatic I	10	0-1	0.1	Sandy clay loam	I	Calamagrostis
		Phreatic II	20-100	0-1	1	Sandy clay loam	I	Scrub; willow

PROFILE



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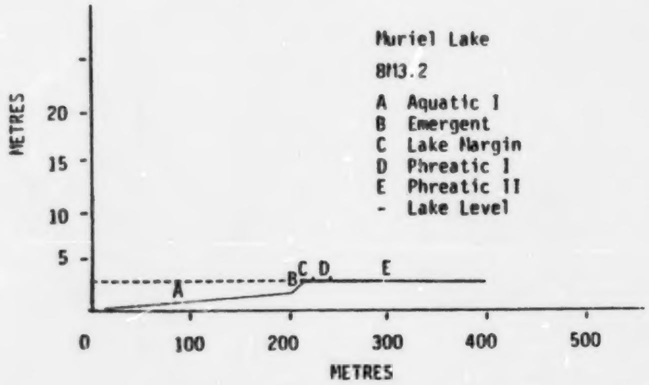
* D - Depositional
E - Erosional
I - Inactive Erosional

LAKE: MURIEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8M3.2 continued	700	Phreatic II	20-100	0 - 1	1	Sandy clay loam	I	Scrub; willow

PROFILE



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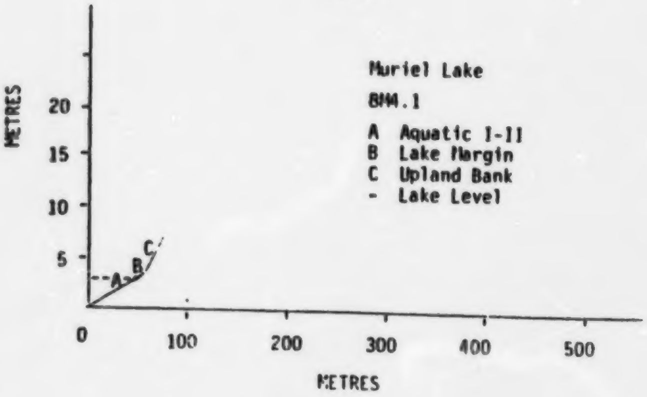
* I - Inactive

LAKE: MURIEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
BM4.1	1 000	Aquatic I-II	50	7	4	Silt	D	Potamogeton pectinatus or Potamogeton vaginatus (sparse)
		Lake Margin	2	10	1	Cobbles	I	
		Upland Bank		16-30		Clay loam	I	Closed mixedwood forest; aspen

A common shoreline type along the north shore of Muriel Lake

PROFILE



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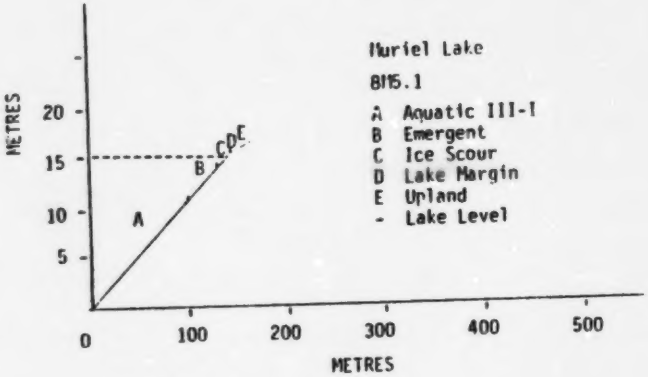
* D - Depositional
I - Inactive

LAKE: MURIEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status	Vegetation
BM5.1	3 000	Aquatic III-I	100	11	3	Sandy		Potamogeton pectinatus
		Emergent	30	11	1-0.5	Sandy		Scirpus validus
		Ice Scour	10	11	0.5	Sandy		
		Lake Margin	1	16-30	0.3	Sand and cobbles		
		Upland		5		Loamy till		Open mixedwood forest; aspen

PROFILE



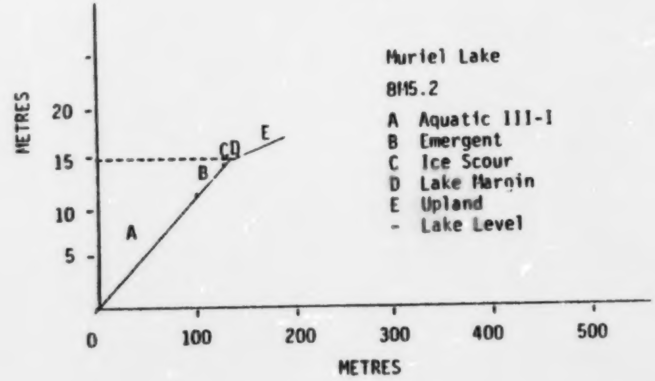
LAKE: MURIEL

Shoreline Type	Length (m)	Level	Lake Level Increase	Lake Level Decrease
8F1.1	400		Similar to 8M7.1	Similar to 8M7.1
8FQ1.1	600	0.2	Beach reduced by 5 m	Beach increased by 5 m
		0.5	Beach eliminated, erosion, falling trees	Beach increased by 20 m
		1.0	Erosion, falling trees, beach eliminated	Beach increased by 50 m
8M3.1	2 000	0.2	Erosion, falling trees	Little change
		0.5	Erosion, falling trees	Emergent reduced
		1.0	Erosion, more falling trees	Emergent reduced, Aquatic I reduced
8M3.2	700	0.2	Reduction of Phreatic I, willow die-off	Reduction of Emergent I, possible species change of Aquatic I
		0.5	Phreatic I eliminated, Emergent eliminated, willow die-off, species change in Aquatic I	Emergent eliminated, Aquatic I eliminated
		1.0	As above plus aspen die-off	Emergent eliminated, Aquatic I eliminated
8M4.1	1 000		Similar to 8M9.2	Similar to 8M9.2
8M5.1	3 000	0.2	Some erosion, ice scour zone could increase	Ice scour zone could increase
		0.5	Erosion, falling trees, ice scour zone increase, Emergent decrease by 15 m	Ice scour zone increased, Emergent reduced by 15 m, Aquatic I reduced

LAKE: MURIEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status	Vegetation
BM5.2	Similar to BM5.1 except 1 100	Lake Margin	10	2-5	0.3	Sandy beach		

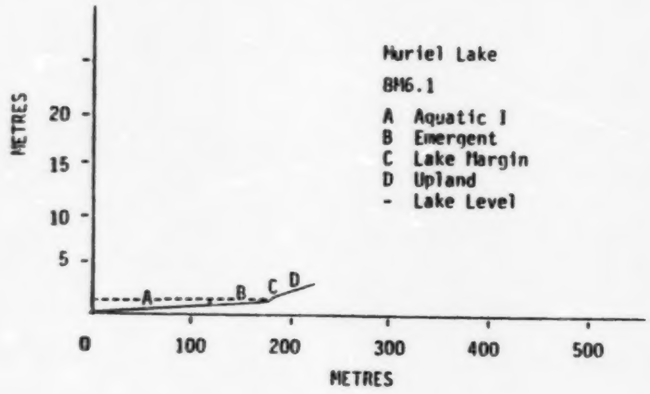
PROFILE



LAKE: MURIEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8M6.1	1 300	Aquatic I	120	1	1	Silt	D	Potamogeton pectinatus, Myriophylum exalbescens,Uticularis vulgaris (dense)
		Emergent	60	1		Silt	D	Scirpus validus, Carex spp.
		Lake Margin	1	10		Cobbly	I	
		Upland		2-5			I	Disturbed, hay field

PROFILE



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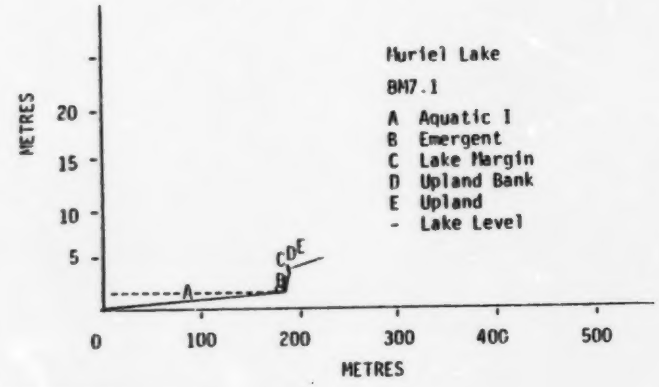
* D - Depositional
I - Inactive Erosional

LAKE: MURIEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
BM7.1	9 500	Aquatic I	180	1	2-7	Silt	D	Potamogeton pectinatus (sparse)
		Emergent	10	1	0.5	Silt	D	Scirpus validus (sparse)
		Lake Margin	1-2	31-45	0.5	Cobbles & boulders	I	
		Upland Bank	2	46-70	1		E	Grasses
		Upland		2-9		Stoney, loamy till		Closed mixedwood forest; aspen

PROFILE



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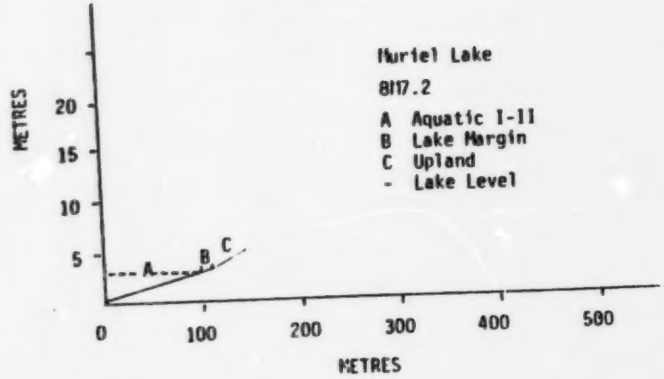
* D - Depositional
I - Inactive Erosional
E - Erosional

LAKE: MURIEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8117.2	300	Aquatic I-II	100	3	3	Silt	D	Utricularia vulgaris, Potamogeton pectinatus
		Lake Margin Upland	5-20	3 2-9	1	Sandy beach Beach sand, veneer over till	D-E I	Closed mixedwood forest; aspen, balsam poplar

PROFILE



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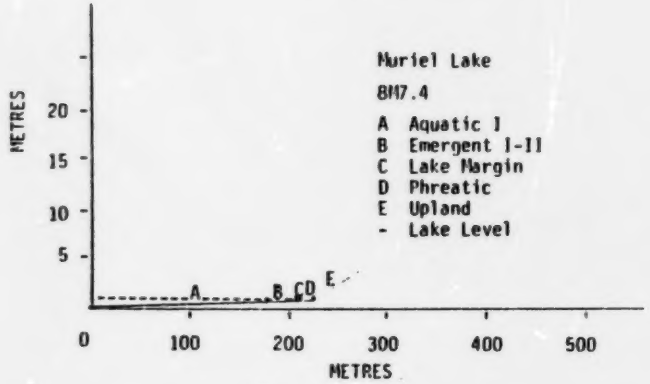
* D - Depositional
E - Erosional
I - Inactive Erosional

LAKE: MURIEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
BM7.4	1 500	Aquatic I	Similar to BO1.1					
		Emergent I-II	Similar to BO1.1					
		Lake Margin	1	0-1	0.2			
		Phreatic	0-30	0-1	0.2	Sandy, organic	I	Scrub; willow
		Upland		2-20				

PROFILE



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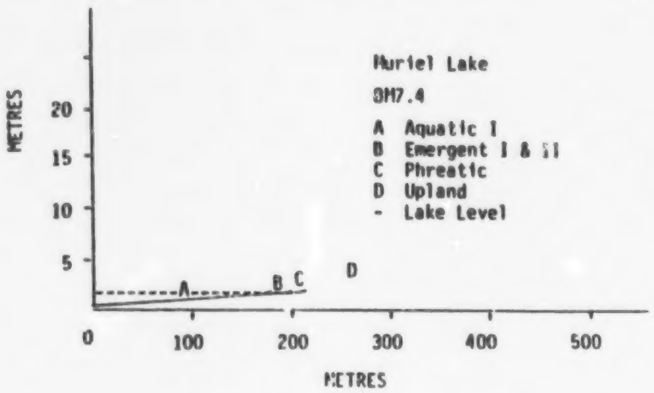
* I - Inactive Erosional

LAKE: MURIEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
BM7.4 continued	2 000	Aquatic I	Similar to BQ1.1				D	
		Emergent I & II	Similar to BQ1.1				D	
		Phreatic	5-20	0-1			I	Scrub; willow
		Upland					I	Closed mixedwood forest; aspen

PROFILE



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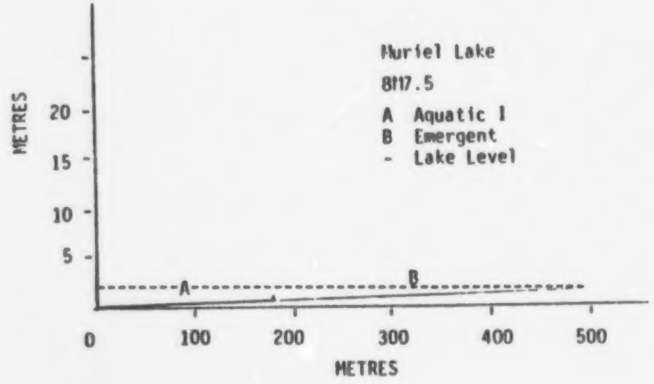
* D - Depositional
I - Inactive Erosional

LAKE: MURIEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8M7.5	2 000	Aquatic I	180 +	0 - 1	1	Silty, organic	D	Utricularis vulgaris, Potamogeton pectinatus (dense)
		Emergent	300	0 - 1	0.5	Silty		Phragmites communis, Scirpus validus, Nuphar variegatum (dense)

PROFILE



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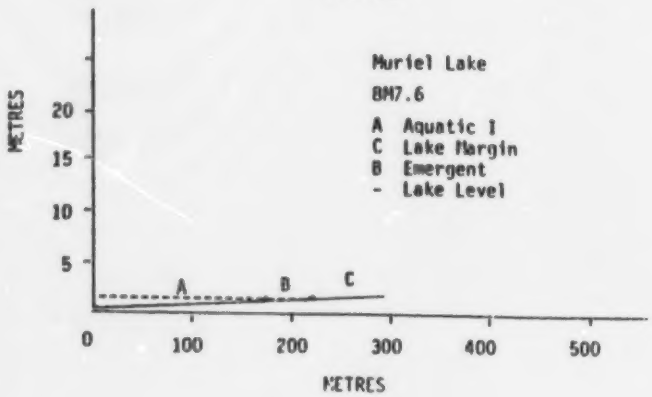
* D - Depositional

LAKE: MURIEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
BM7.6	250	Aquatic I	180	1	2	Silt	D	Potamogeton pectinatus (sparse)
		Lake Margin	30-60	0-1	1	Sand, sand and cobbles		
		Emergent		0-1				Scirpus validus (dense)

PROFILE



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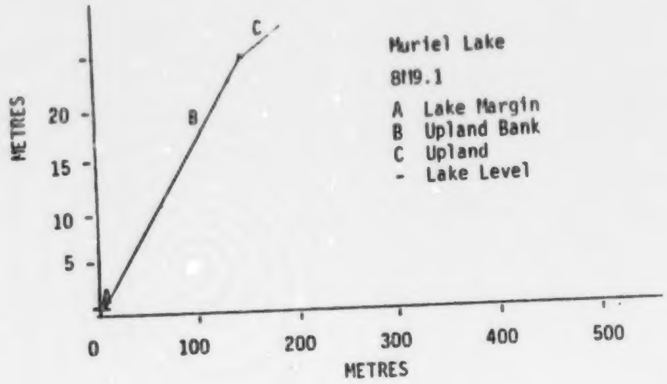
* D - Depositional

_AKE: MURIEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status *	Vegetation
8M9.1	2 000	Lake Margin	2 - 5	16-30	0.5	Cobbles & boulders	I	
		Upland Bank	250	16-30	40	Stoney, loamy till	I-E	Closed mixedwood forest; aspen
		Upland		9-15		Stoney, loamy till	I	Closed mixedwood forest; aspen

The prevalent wind direction is on shore, which has effectively eliminated aquatic macrophytes for the shoreline.

PROFILE



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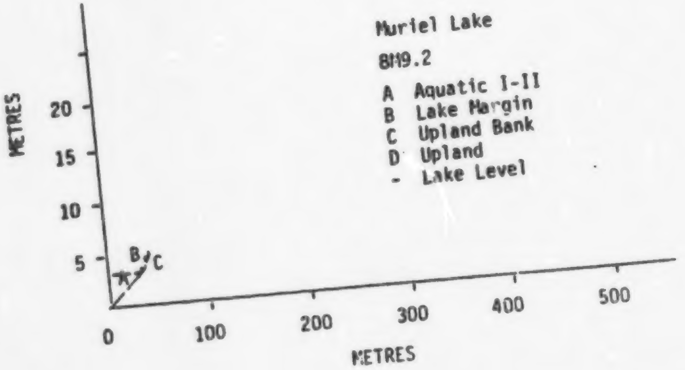
* E - Erosional
I - Inactive Erosional

LAKE: MURIEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status	Vegetation
8H9.2	4 500	Aquatic I-II	32	10	3	Soft silt		Potamogeton vaginatus (sparse)
		Lake Margin	1	20	0.2	Cobbles		
		Upland Bank	0.5	25	1	Sand		
		Upland				Sand		Closed aspen forest

Note the cobbly lake margin.

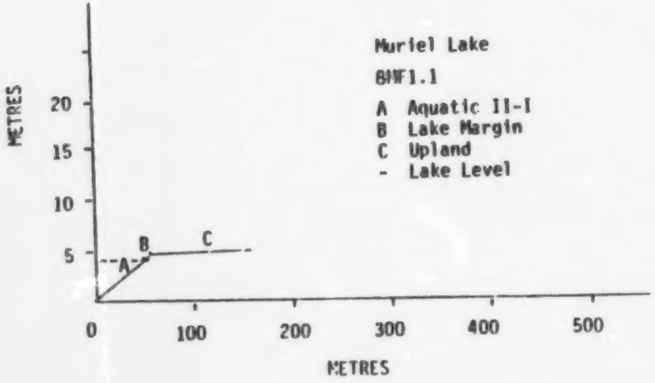
PROFILE



LAKE: MURIEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status	Vegetation
BMF1.1	1 000	Aquatic II-I	50-0	8	4	Silt		Potamogeton vaginatus, filamentous green algae (dense)
		Lake Margin Upland	5	10 0-1	1	Sandy beach Sand		Disturbed - cottages

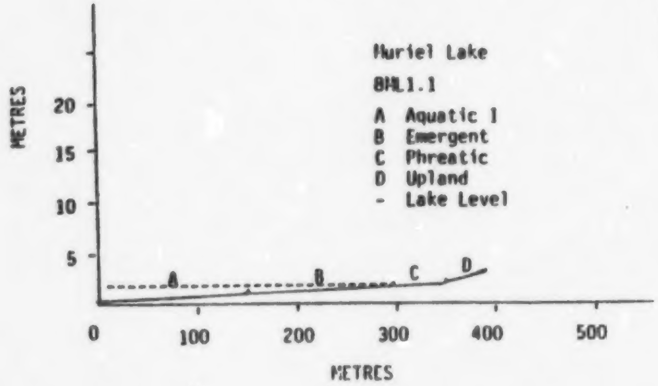
PROFILE



LAKE: MURIEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status	Vegetation
BML1.1	500	Aquatic I	150	1	1.72-0.75	Silt, organic	D	Potamogeton pectinatus (dense)
		Emergent	150	1	0.75	Silt, organic	D	Phragmites communis, Scirpus validus
		Phreatic	50	1	0.5	Silt, organic	I - D	Scrub; willow
		Upland		2-5		Loamy	I	Closed mixedwood forest; aspen

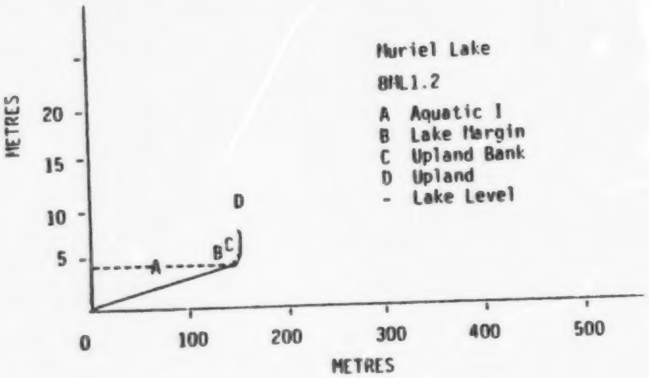
PROFILE



LAKE: MURIEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status	Vegetation
8ML1.2	600	Aquatic I	150	3	1.75	Sand	E - D	Potamogeton pectinatus, Chara spp.
		Lake Margin	2	16-30	0.5	Sand beach	E - D	
		Upland Bank	15	100	0.5	Sand	E	
		Upland				Sand	I	Open mixedwood forest; aspen, balsam poplar

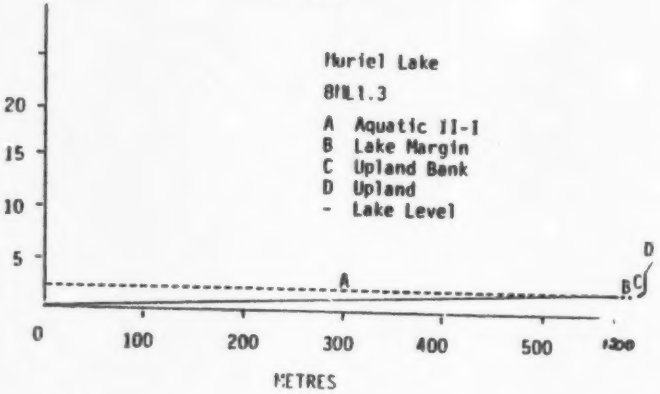
PROFILE



LAKE: MURIEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status*	Vegetation
8ML1.3	4 200	Aquatic II-1 Lake Margin and Upland similar to 8ML1.2	1 200	1	4	Sand, silt	D	

PROFILE



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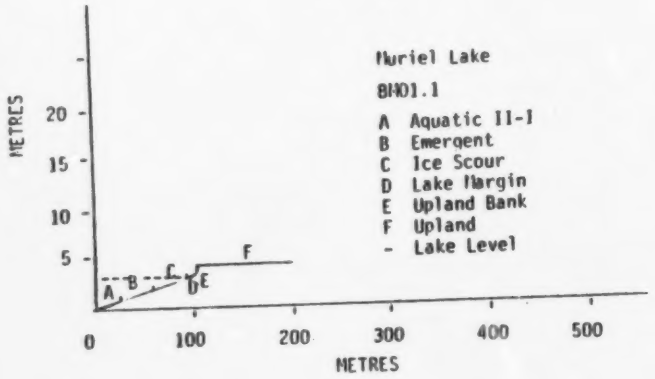
[*] D - Depositional

LAKE: MURIEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status*	Vegetation
BMQ1.1	2 000	Aquatic II-I	20	3	1	Silt	D	Potamogeton pectinatus
		Emergent	40	3	1	Silt, sandy silt	E	Scirpus (medium)
		Ice Scour	40	3	0.8	Sand	E	Chara (sparse)
		Lake Margin	3	16-30	0.5	Sand	E	
		Upland Bank	0.5	100+	0.5	Sand	I	Sparse vegetation
		Upland		0-1		Sand terrace		Closed mixedwood forest; aspen

PROFILE



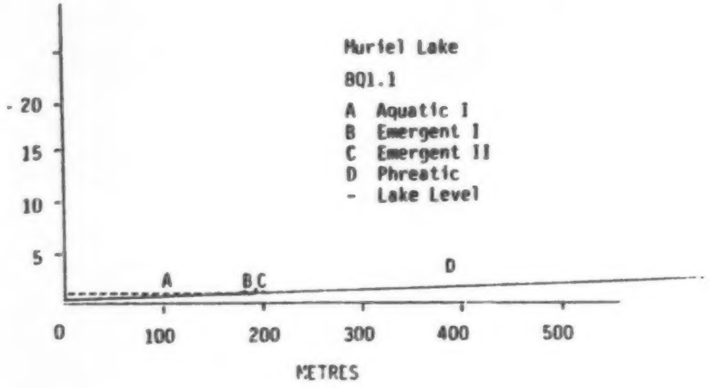
* D - Depositional
E - Erosional
I - Inactive Erosional

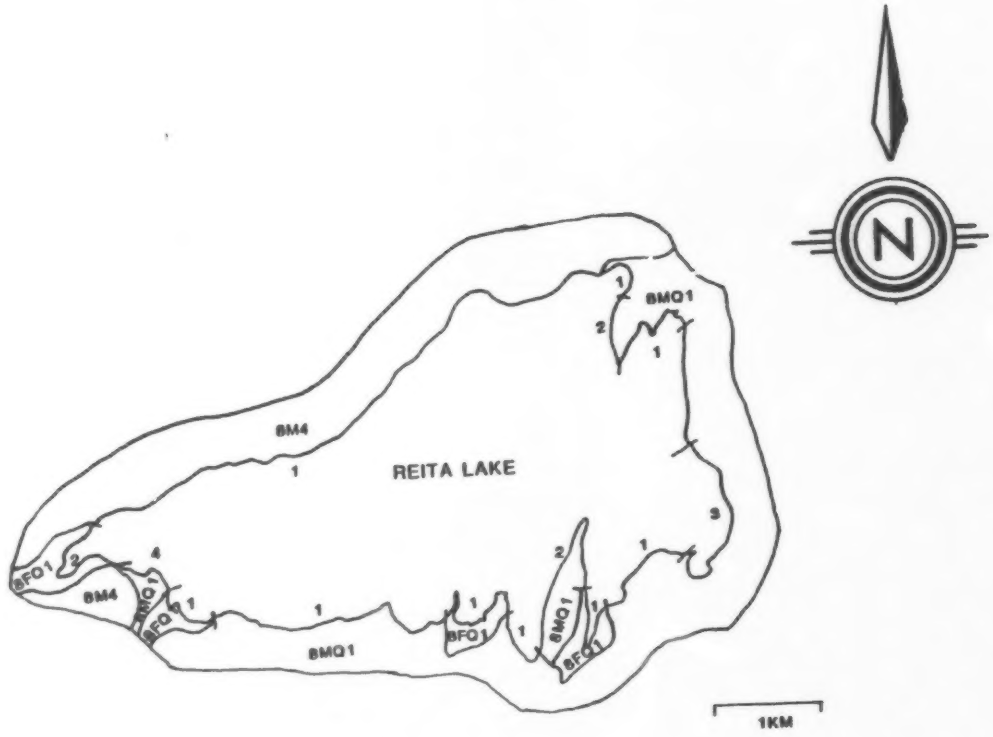
LAKE: MURIEL

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status	Vegetation
8Q1.1	500	Aquatic I	180+	0 - 1	1.75	Silt, organic	D	Utricularia vulgaris, Potamogeton pectinatus
		Emergent I	20-30	0 - 1	1	Silt, organic	D	Phragmites communis, Scirpus validus, Nuphar variegatum
		Emergent II	15-10	0 - 1	0.2	Silt, organic	D	Carex spp., Typha latifolia
		Phreatic	600	0 - 1	0.3	Organic	I	Open mixedwood forest; balsam poplar, willow

This area provides important nesting habitat for birds.

PROFILE



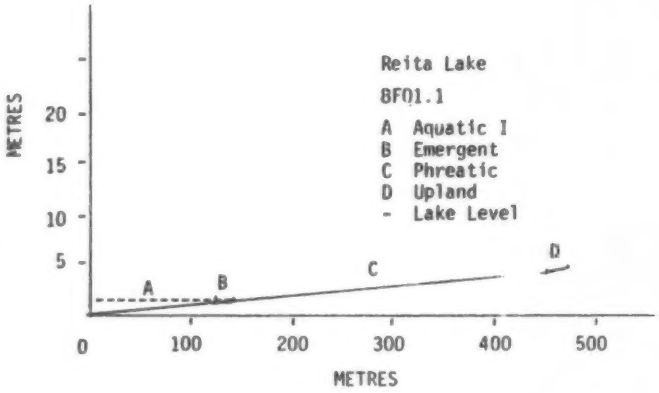

N
BMQ1
1
2
1
BM4
1
REITA LAKE
3
1
2
4
BFQ1
2
BM4
BMQ1
BFQ1
1
1
1
BFQ1
1
BMQ1
1
BFQ1
BMQ1
1KM

LAKE: REITA

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status *	Vegetation
8FQ1.1	3 000	Aquatic I	130 - 20	1	1-0.1	Soft silt	D	Myriophylum exalbescens and Potamogeton filiformis (dense) Some sparse Nuphar variegatum
		Emergent	20 - 0	1	0.1-0	Soft silt	D	Carex aquatilis
		Phreatic	30 - 500	1	0-1	Silt, organic	D	Calamagrostis inexpansa, Mentha arvense
		Upland		2-5	5			Open aspen forest

Shoreline 8FQ1.1. This photo of the shoreline illustrates the relatively flat topography of this lake.

PROFILE



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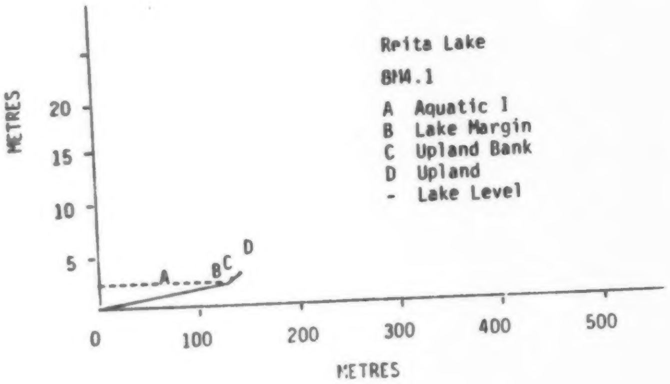
* D - Depressional

LAKE: REITA

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8M4.1	5 500	Aquatic I	125	2	2	Soft silt	D	Potamogeton myriophylum
		Lake Margin	2	5-9	1	Sand	D	Sandy beach
		Upland Bank	2	5-9	2	Sand	E	Sparse vegetation - ice push
		Upland		5-9		Stoney		Closed aspen forest; aspen/rose, raspberry/fireweed, coltsfoot

This is a photograph of shoreline 8M4.1. It is typical of most of the south shore of Reita Lake. The lake margin of the ecotype alternates from vegetated to unvegetated and shows evidence of ice push in the less vegetated areas.

PROFILE



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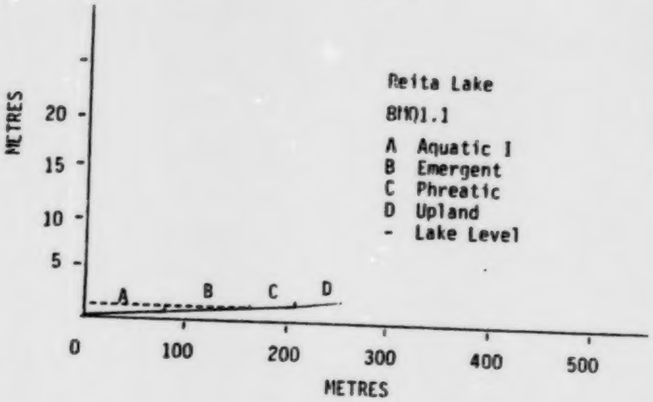
* D - Depressional
E - Erosional

LAKE: REITA

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8MQ1.1	6 000	Aquatic I	80	1	1	Silt & cobbles	I	Potamogeton filiformis
		Emergent	85	1	1	Silt & cobbles	I	Scirpus validus
		Phreatic	65	1	0.6	Silt and organic	I	Scrub; willow
		Upland		2-5		Sandy till	I	Closed mixedwood forest; aspen

PROFILE



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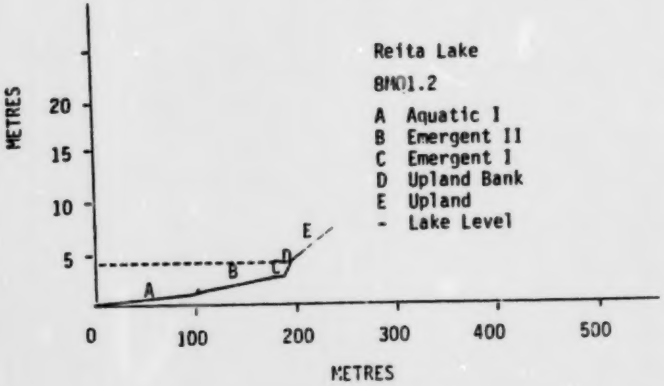
* I - Inactive Erosional

LAKE: REITA

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8MQ1.2	3 100	Aquatic I	100	1	1-2	Hard silt	D	Potamogeton filiformis (medium)
		Emergent II	75	2	0.5-1	Silt	D	Scirpus (medium)
		Emergent I	10	1	0.2	Silt	D	Phragmitic communis, Typha latifolia
		Upland Bank	10	16-30	1-2	Loamy till	E	Scrub; willow
		Upland		2-5		Loamy till	I	Closed mixedwood forest; aspen

PROFILE



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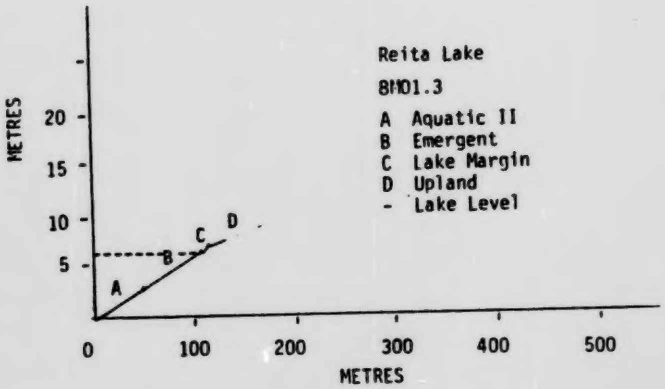
* D - Depressional
E - Erosional
I - Inactive Erosional

LAKE: REITA

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8MQ1.3	1 900	Aquatic II	50	10 - 1	1	Silt	D	Potamogeton filiformis (medium)
		Emergent	70		1 - 25	Silt	D	Carex spp.(dense)
		Lake Margin	3	6 - 9	0.3	Sand & cobbles	I	
		Upland		2 - 5		Sandy till	I	Closed mixedwood forest; aspen

PROFILE



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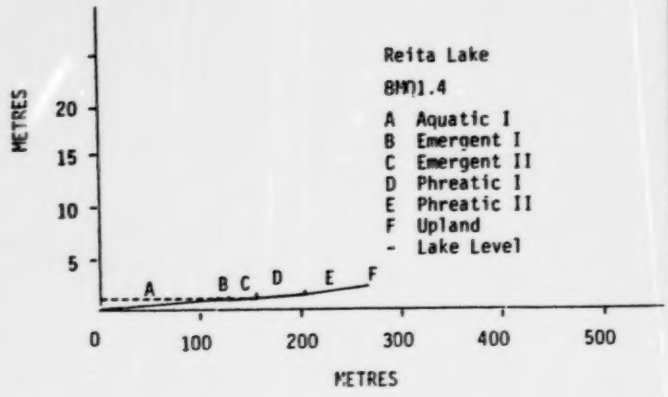
* D - Depressional
I - Inactive Erosional

LAKE: REITA

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8MQ1.4	400	Aquatic I	120	1	0.7	Soft silt	D	Nuphar variegatum, Potamogeton filiformis
		Emergent I	10	0-.5	0.3	Soft silt	D	Scirpus
		Emergent II						Typha (on north shore)
		Phreatic I	0-30	0-1		Organic	D	Carex, willow
		Phreatic II	30-50	0-1		Organic, silt	D	Willow
		Upland		0-2				Closed mixedwood forest

This stereopair is of the large margin zone of Reita Lake in 8MQ1.4. The very flat topography of the ecotype makes it very susceptible in both species composition and erosional status to flooding or desiccation. This is common to most MI deposits.

PROFILE



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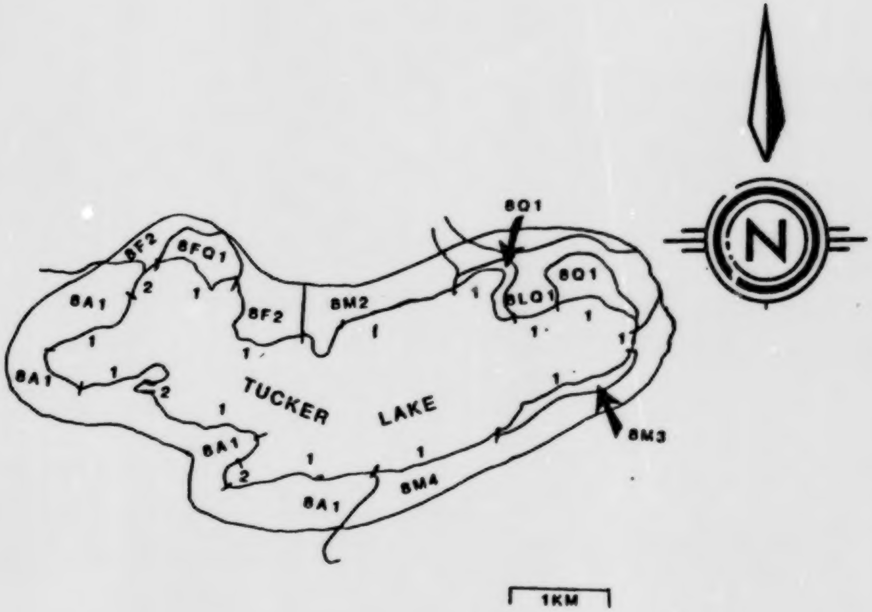
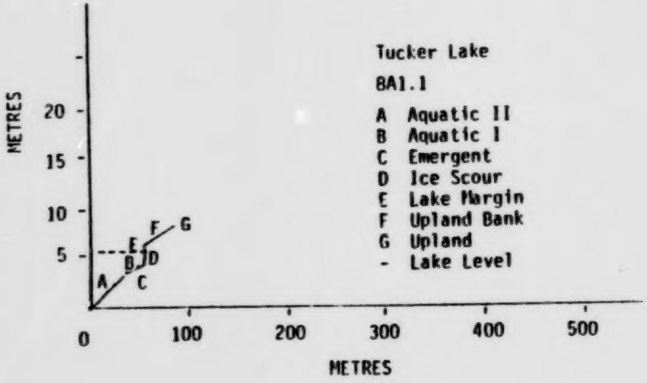
* D - Depressional


8F2
8FQ1
8Q1
8A1
8F2
8M2
8LQ1
8Q1
8A1
TUCKER LAKE
8M3
8A1
8A1
8M4
N
1KM

LAKE: TUCKER

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8A1.1	4 000	Aquatic II	40-35	10	4-2	Hard silt	D	Ceratophyllum spp.(medium)
		Aquatic I	20-10	5	2-0.5	Silt	D	Filamentous green algae (dense)
		Emergent	10-5	5	0.2-0.2	Silt	D	Scirpus (sparse)
		Ice Scour	5-0	5	0.2	Sand	D	Potamogeton richardsonii (sparse)
		Lake Margin		100 +		Sand (undercut)	E	
		Upland Bank	1	100	1	Sand	E	Willow, dogwood
		Upland		6-9			I	Closed aspen forest

PROFILE



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* D - Depositional
I - Inactive Erosional
E - Erosional

LAKE: TUCKER

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8A1.2	500	Aquatic I	70-0	3	25 - 0	Very soft silt	D	Ceratophyllum (dense)
		Lake Margin	0.2	100 +	0.2	Undercut sand	E	
		Upland Bank	1	100	1	Sand	E	Scrub; dogwood, willow
		Upland		0 - 1		Sand	I	Closed aspen forest

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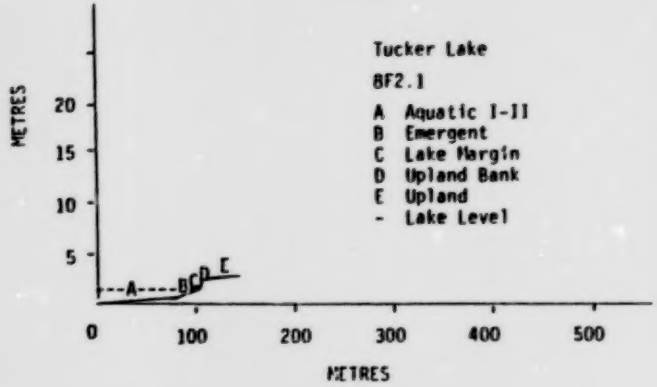
* D - Depositional
E - Erosional
I - Inactive Erosional

LAKE: TUCKER

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
BF2.1	1 100	Aquatic I-II	100-50	1	2 - 3	Silt	D	Ceratophyllum spp. Potamogeton zosterisformis
		Emergent	20-30	4	1.5	Silt	D	Nuphar variegatum, Scirpus validus
		Lake Margin	3 - 5	2-5	0.1	Sand	D	
		Upland Bank	5	46-100	5	Sand & gravel; terraced	E	Closed mixedwood forest; aspen
		Upland		0-1		Sand, terraced		Closed mixedwood forest; aspen

PROFILE



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* D - Depositional
E - Erosional

LAKE: TUCKER

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8F2.2	300	Aquatic II	100-60	4	4-3	Silt	D	Ceratophyllum (medium)
		Emergent	60-10	4	3-0.5	Silt	D	Nuphar variegatum
		Ice Scour	10-0	4	0.5	Sand	E	
		Upland Bank	5	46-100	5	Sand	E	Closed mixedwood forest; aspen
		Upland		0-1		Sand, gravel, terraced	I	

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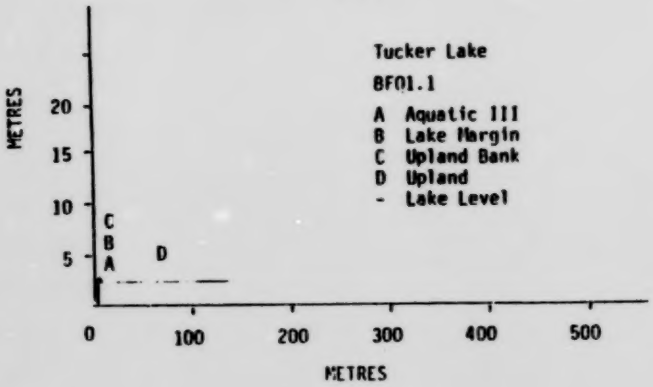
* D - Depressional
E - Erosional
I - Inactive Erosional

LAKE: TUCKER

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
BFQ1.1	600	Lake Margin	0.3	100+	0.3	Undercut sand	E	
		Upland Bank	1	100	1	Stoney sand	E	Scrub; willow, dogwood
		Upland		0-1				Closed deciduous forest; balsam poplar
		Aquatic III	160-100	3	4.7-4	Silt	D	Ceratophyllum and Filamentous green algae (sparse)

PROFILE



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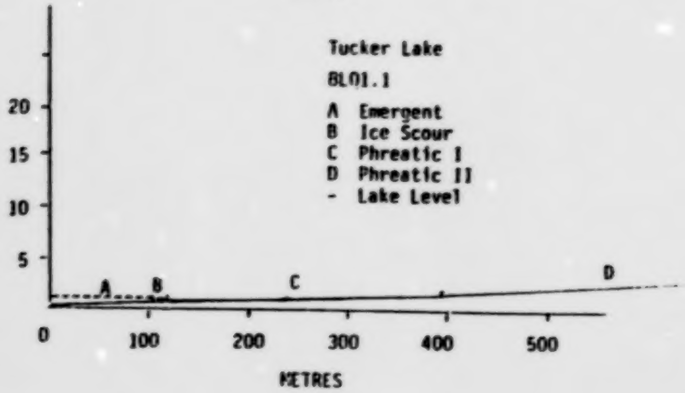
* E - Erosional
D - Depositional

LAKE: TUCKER

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
BL01.1	500	Emergent	150-20	1	1.5 - 1	Soft silt	D	Nuphar variegatum (dense)
		Ice Scour	20 - 0	1			F	Not sampled
		Phreatic I	50-450	0-1	1 - 2	Organic & clay	I	Phragmites, Carex, Willow
		Phreatic II	450-550	0-2				Open coniferous forest; black spruce, tamarack

PROFILE



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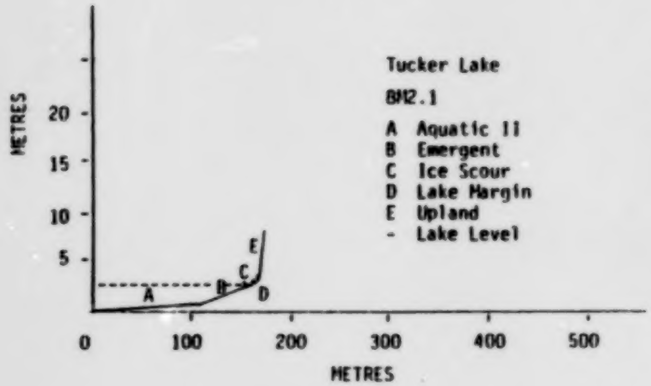
* D - Depositional
E - Erosional
I - Inactive Erosional

LAKE: TUCKER

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8M2.1	1 500	Aquatic II	100-50	1	3-2	Silt	D	Ceratophyllum spp., Potamogeton zosterisformis
		Emergent	50-10	4	2-0.5	Silt	D	Nuphar variegatum
		Ice Scour	10-0	4	0.4		E	Not sampled
		Lake Margin	2	36-45	0.5	Undercut sand	E	
		Upland		46-100	15	Sandy & stoney	I	Open aspen forest

Ecotype 8M2.1. A profile view of the ecotype.

PROFILE



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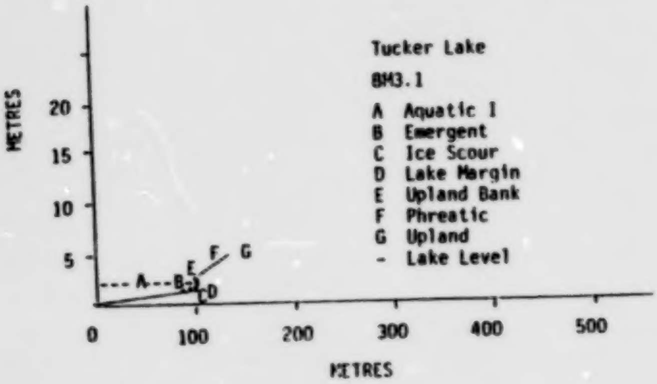
[*] D - Depositional
E - Erosional
I - Inactive Erosional

LAKE: TUCKER

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8M3.1	1 100	Aquatic I	90-5	1.5	1.5-0	Silt	D	Potamogeton pectinatus
		Emergent	5-2	1.5		Silt	D	Scirpus validus (sparse)
		Ice Scour	2-0	1.5			E	Not sampled
		Lake Margin	0.5	100+	0.5	Undercut sand	E	
		Upland Bank	0.5	100	0.2-0.5			
		Phreatic				Sand, organic	E	Scrub; willow
		Upland		6-30		Sandy, stoney till		Closed mixedwood forest; spruce

Ecotype 8M3.1. A view of the Phreatic belt - Tucker Lake.

PROFILE



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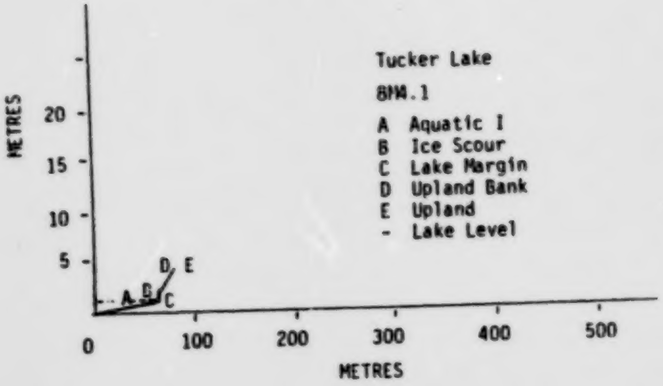
* D - Depositional
E - Erosional

LAKE: TUCKER

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
BM4.1	1 000	Aquatic I	60-10	2	1.5-0.5	Hard silt	D	Potamogeton richardsonii, Myriophyllum exalbescens. Potamogeton pectinatus (dense) Ceratophyllum (sparse)
		Ice Scour	10-0	2	5-0	Hard sand	E	
		Lake Margin	0.2	100 +	0-0.2	Undercut till	E	
		Upland Bank	1	100	0	Sandy stoney till	E	Scrub; willow, dogwood
		Upland		6-30		Sandy stoney till	E	Closed mixedwood forest; spruce

PROFILE



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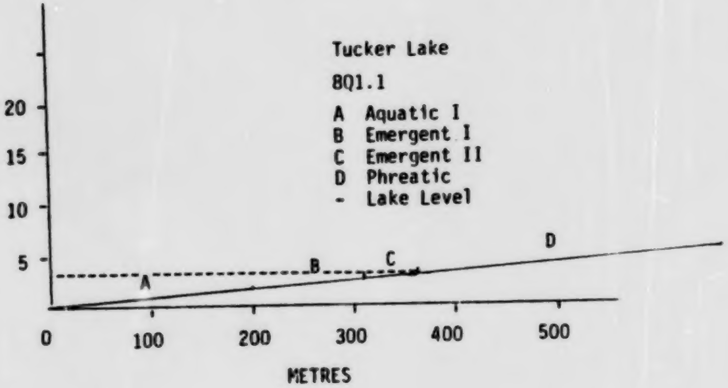
* D - Depositional
E - Erosional

LAKE: TUCKER

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8Q1.1	1 500	Aquatic I	200-150	1	2-1.0	Soft silt	D	Ceratophyllum spp., Potamogeton zosterisformis (dense)
		Emergent I	150-50	1	1-0.5	Soft silt	D	Nuphar variegatum (dense)
		Emergent II	50	1	0.5	Soft silt	D	Scirpus validus (sparse)
		Phreatic	500	1	1-5	Organic	I	Open coniferous forest; tamarack/willow

PROFILE



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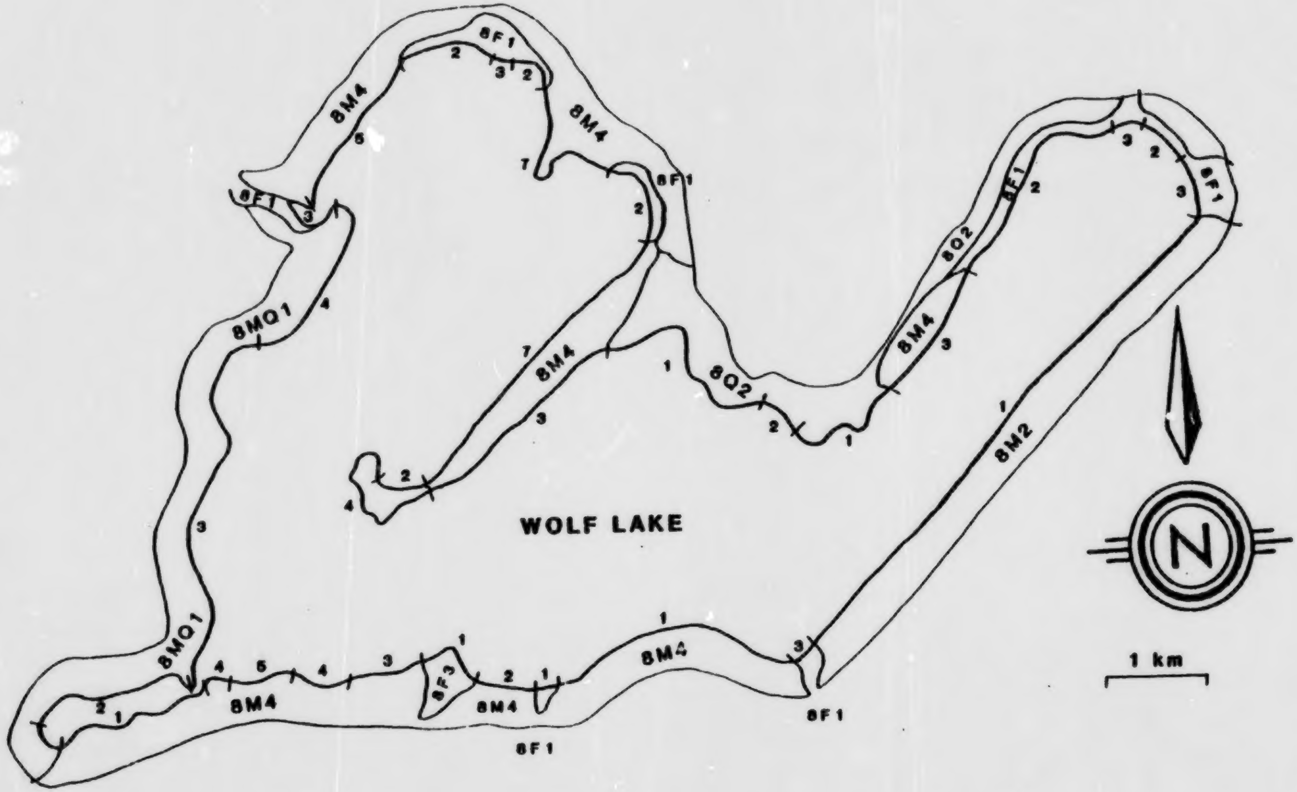
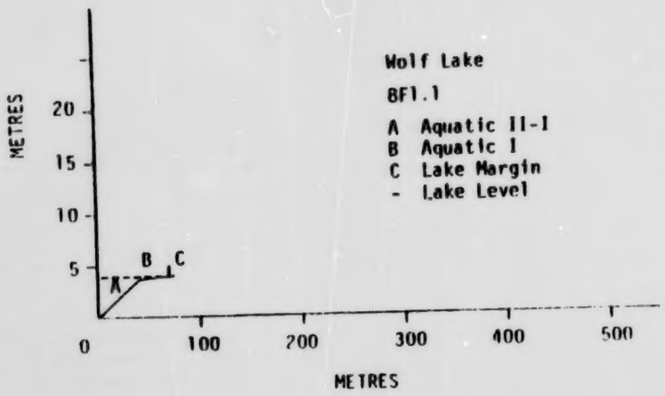
* D - Depositional
E - Erosional


8F1
8M4
8F1
8F1
8MQ1
8M4
8F1
8Q2
8M4
8Q2
8F1
8M4
8M2
WOLF LAKE
8MQ1
8M4
8F3
8M4
8F1
8M4
8F1
N
1 km

LAKE: WOLF

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
BF1.1	150	Aquatic I	100	4		Sandy	D	Potamogeton friesii, Myriophyllum exalbescens (very sparse)
		Lake Margin	2	16-30	0.5	Sandy, sparse cobbles	E	
		Upland Bank	40	16-30	10	Sandy loam	I	Closed mixedwood forest; spruce-aspen (feathermoss)
		Aquatic II-I	40	7-10	3	Sand	D	
		Aquatic I	30	1	1	Sand	D	
		Lake Margin	5	2-5	0.5	Sand beach	D	
		Phreatic						Scrub; willow, dogwood forest; aspen,balsam poplar/fireweed

PROFILE



* D - Depositional
E - Erosional
I - Inactive Erosional

LAKE: WOLF

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8F1.2	5 000	Aquatic		8		Sand	D - E	
		Lake Margin		6-9	0.3	Sand beach	D	Closed mixedwood forest; aspen, spruce
		Upland		6-9		Sandy till	I	

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* D - Depositional
E - Erosional
I - Inactive Erosional

LAKE: WOLF

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8FI.3	1 850	Aquatic I		4		Sandy	D	Potamogeton friesii, Myriophyllum exalbescens (very sparse)
		Lake Margin	2	16-30	0.5	Sand, sparse cobbles	E	
		Upland Bank	40	16-30	10	Sandy loam	I	Closed mixedwood forest; spruce-aspen (feathermoss)

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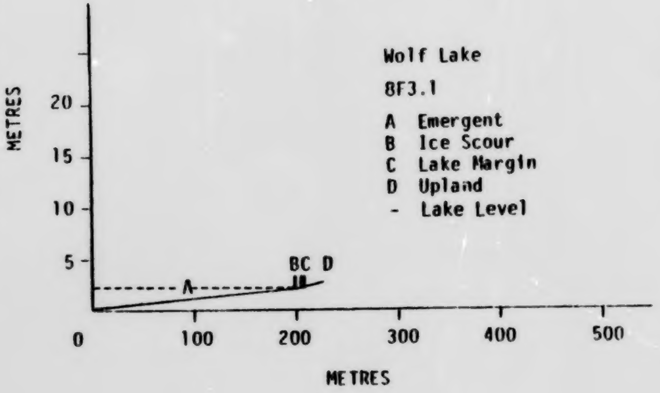
* D - Depositional
E - Erosional
I - Inactive Erosional

LAKE: WOLF

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8F3.1	550	Emergent	200	1	2	Sand	D	Scirpus validus
		Ice Scour	5	1	0.3	Cobbles & sand	E - I	
		Lake Margin	1	2 - 5	0.5	Cobbles & boulders	I	
		Upland		2 - 5		Sandy loam veneer over till	I	Closed mixedwood forest; spruce, aspen

PROFILE



* D - Depositional
E - Erosional
I - Inactive Erosional

LAKE: WOLF

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
RM2.1	5 500	Aquatic		6		Sandy	E	No plants
		Lake Margin	1	31-45	0.5	Cobbly	I	Closed coniferous forest; spruce/feathermoss
		Upland Bank	70	31-45	25	Sandy loam	E	

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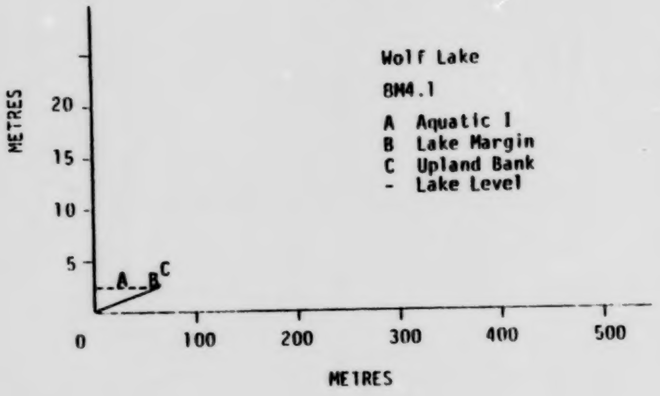
* E - Erosional
I - Inactive Erosional

LAKE: WOLF

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8M4.1	4 000	Aquatic I	60	4	0.2	Soft silty sand		Potamogeton friesii, Myriophyllum exalbescens (sparse)
		Lake Margin	1	16-30	0.2-0.5	Cobbly	I	Closed mixedwood forest; aspen-spruce/alder/feathermoss
		Upland Bank	1	16-30		Clay loam		

PROFILE



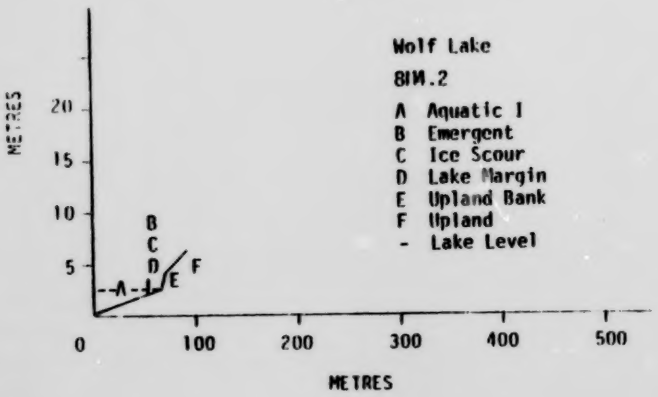
* I - Inactive Erosional

LAKE: WOLF

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8M4.2	1 050	Aquatic I	55	4	2	Sand	D	Chara globularis (sparse)
		Emergent	5	4	1-0.5	Sand	D	Scirpus validus
		Ice Scour	5	4	0.5-0	Sand	D	Chara globularis (sparse)
		Lake Margin	1	16-30	0.5	Cobbles and boulders	I	
		Upland Bank	3	31-45	1	Sandy loam till	E	Scrub; dogwood
		Upland		10-15		Sandy loam till	I	Closed mixedwood forest; spruce, aspen

Shoreline Type 8M4.2. This shoreline type is located on 10-15% slopes on the left half of the photograph.

PROFILE

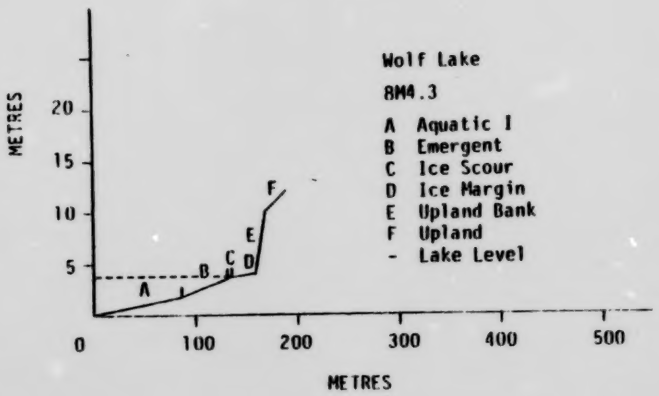


* D - Depositional
E - Erosional
I - Inactive Erosional

LAKE: WOLF

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8M4.3	4 450	Aquatic I	85	2	2	Sand	D	Myriophyllum exalbescens.
		Emergent	45	4	1.5	Sand	D-E	Scirpus validus
		Ice Scour	5	4	0.3	Cobble and sand	E	
		Lake Margin	2	15-30	0.5	Cobbles & boulders	I	
		Upland Bank	10	46-70	5	Sandy loam till	E	Scrub; dogwood, willow
		Upland		10-15		Sandy loam till	I	Closed mixedwood forest; spruce, aspen

PROFILE

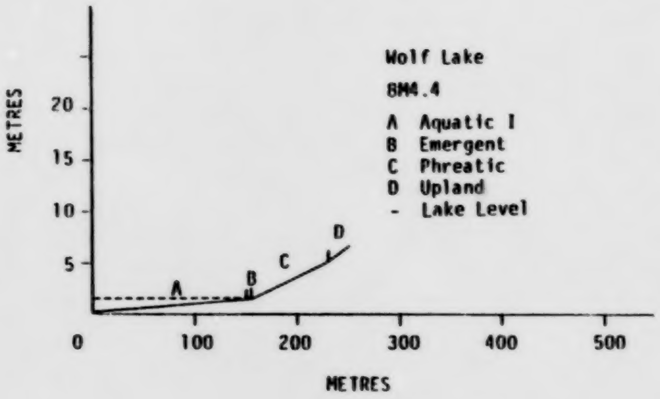


* D - Depositional
E - Erosional
I - Inactive Erosional

LAKE: WOLF

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
BM4.4	2 300	Aquatic I	150 +	1	1.5-0.2	Silt	D	Ceratophyllum spp., Myriophyllum exalbescens, Chara globularis (dense)
		Emergent	5	1	0.2	Silt, organic	D	Typha latifolia, Carex spp., Calamagrostis inexpansa
		Phreatic	75	5	2	Silt, organic	D	Scrub; willow
		Upland		6-9		Clay loam till	I	Closed mixedwood forest; spruce, aspen

PROFILE



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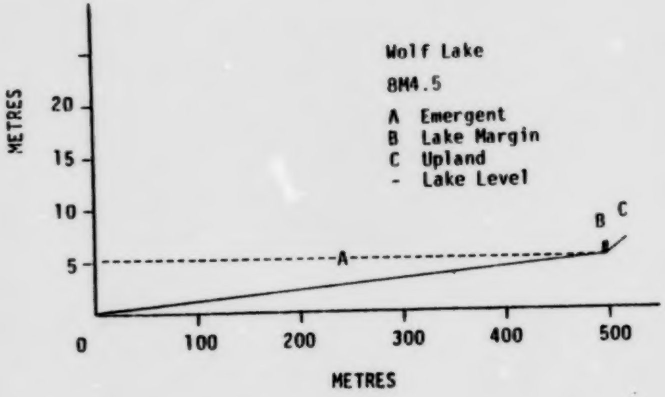
* D - Depositional
I - Inactive Erosional

LAKE: WOLF

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8M4.5	600	Emergent	500	0-1	1	Silt, sand, organic	D	Scirpus validus, Nuphar variegatum, Ceratophyllum (dense)
		Lake Margin	1	6-9	0.1	Sand and cobbles	I	Closed mixedwood forest; aspen, spruce
		Upland		6-9		Clay loam till	I	

PROFILE



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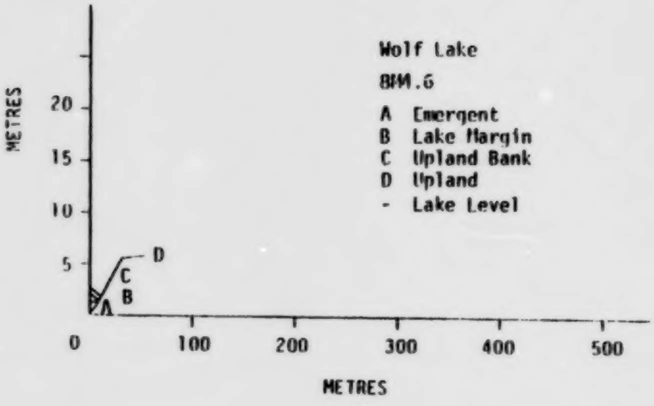
* D - Depositional
I - Inactive Erosional

LAKE: WOLF

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
BM.6	1 650	Emergent	10	15	1.5	Sand	I	Scirpus validus
		Lake Margin	1	16-30	0.3	Cobbles & sand	I	
		Upland Bank	20	16-30	6	Sandy till	I	Open mixedwood forest; aspen
		Upland		0-1		Sandy till	I	Open mixedwood forest; aspen, spruce

PROFILE



I - Inactive Erosional

LAKE: WOLF

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8M4.7	5 000	Aquatic		10			I	No vegetation
	Similar to 8M4.1							

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* I - Inactive Erosional

LAKE: WOLF

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
BM4.8	300	Aquatic II-1		5		Sand	D	No vegetation
		Emergent	20	5	0.7	Sand	D	Scirpus validus (sparse)
		Ice Scour	5	5	0.3	Sand	D-E	Chara globularis (sparse)
		Lake Margin	1	34-70		Cobbles & boulders		
		Upland		31-70				Closed mixedwood forest; spruce/ feathermoss

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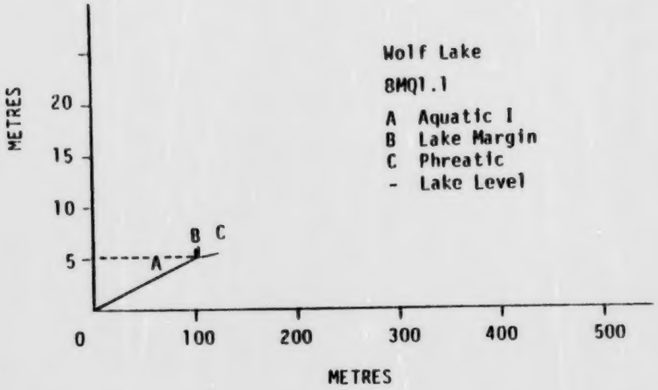
* D - Depositional
E - Erosional

LAKE: WOLF

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8MQ1.1	1 750	Aquatic I	100	5	5	Silt	I	Potamogeton friesii, Myriophyllum exalbescens
		Lake Margin	2	10-15	0.3	Cobbles and sand	I	
		Phreatic		0-1		Silt & organic		Scrub; willow

PROFILE



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* I - Inactive Erosional

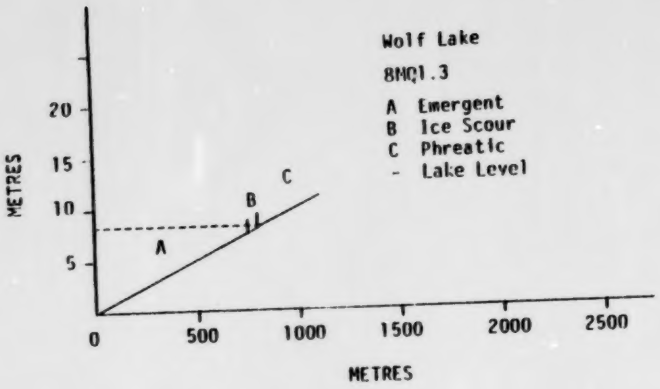
LAKE: WOLF

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion Status	Vegetation
8MQ1.2	1 700	Similar to 8M4.1				Soft, silty sand		

LAKE: WOLF

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8MQ1.3	3 600	Emergent	500-1000	1	1.7-0.5	Sand	I	Scirpus validus, Ceratophyllum spp., Potamogeton sp.
		Ice Scour	50	1	0.5	Sand	I	Scrub; willow
		Phreatic	300	1		Silt, organic	I	

PROFILE

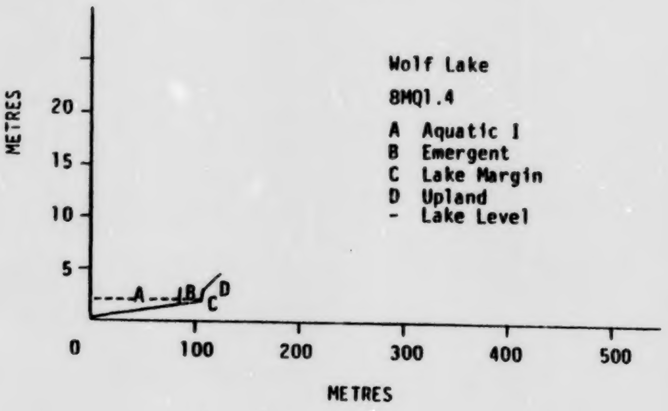


* I - Inactive Erosional

LAKE: WOLF

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8MQ1.4	1 750	Aquatic I	85	2	1.5	Silt	D	Potamogeton vaginatus, Potamogeton praelongis
		Emergent	20	2	0.5			
		Lake Margin	1	100	1	Cobbles and boulders	E	
		Upland		6-9		Loam till	I	Closed mixedwood forest; aspen, birch, spruce

PROFILE



* D - Depositional
E - Erosional
I - Inactive Erosional

LAKE: WOLF

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion * Status	Vegetation
8Q2.1	3 500	Aquatic II		1	2	Sand	D	Potamogeton praelongis, Myriophyllum exalbescens (sparse)
		Emergent	200-500	1	1.5	Sand	D	Scirpus
		Ice Scour	20	1	0.5	Sand	D	Chara globularis (sparse)
		Phreatic	500-1000	0-1	0.5-1	Organic	D	Open coniferous forest; black spruce, tamarack

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* D - Depositional

LAKE: WOLF

Shoreline Type	Length (m)	Zone	Width (m)	Slope (%)	Local Relief	Materials	Erosion* Status	Vegetation
8Q2.2	400	Aquatic I	100	1	0.7	Soft silt	D	Ceratophyllum spp., Potamogeton friesii, Nuphar variegatum (dense)
		Emergent II				Silty		Carex spp.
		Emergent I	500	1	1.5	Sandy	D	Scirpus validus
		Phreatic	500-1000	1		Organic		Scrub; willow, birch Meadow; Carex

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* D - Depositional

Appendix III

Impact Prediction of the Effects of Water Level Fluctuation on the Materials and Vegetation by C. McGregor and J. Crosby

LAKE: ANGLING

Shoreline Type	Length (m)	Level	Lake Level Increase	Lake Level Decrease
8M5.1	900	0.2	Flooding of Phreatic zone (20 cm +)	Emergent zone reduction
8M5.2	1 400	0.5	Phreatic zone completely flooded	Emergent zone reduced (50 m) to eliminated
		1	Phreatic zone flooded, some flooding of upland areas, some increased erosion	Emergent zone eliminated, some reduction in the Aquatic zone
8M5.3	1 600	0.2	Some increased erosion of Lake Margin	Some restriction of Emergent zone (20 m)
		0.5	Some erosion of Upland Bank	Emergent reduced or eliminated (50 + m)
		1	Extensive erosion of Upland Bank	Emergent eliminated, Aquatic I reduced
8M6.1	2 000	0.2	Some increased erosion of Lake Margin	Aquatic I reduced (20 m)
		0.5	Some erosion of Upland Bank	Aquatic I reduced (50 m +)
		1	Extensive erosion of Upland Bank	Aquatic I eliminated
8M6.3	2 800	0.2	No change	Aquatic I reduced (10 m)
		0.5	Increased erosion	Aquatic I reduced (25 m)
		1	Increased erosion	Aquatic I eliminated

LAKE: BURNT

Shoreline	Length (m)	Level	Lake Level Increase	Lake Level Decrease
8FQ1.1	1 000	0.2	Some flooding of Phreatic zone	Some reduction (20 m) of Aquatic I
		0.5	Extensive flooding of Phreatic zone	Extensive reduction of Aquatic I (50 m)
		1.0	Extensive flooding of Phreatic zone	Extensive reduction of Aquatic I (100 m)
8M1.1	3 000	0.5	Increased erosion, fallen trees	No change
		1.0	Increased erosion, fallen trees	No change
8MQ1.2	1 500	0.2	Some increased erosion	No change
8MQ1.1	1 500	0.2	No change	No change
8LQ1.1	1 500	0.5	Beach flood, some Phreatic flooding	Small reduction in Aquatic I
8Q1.1	500	1.0	Beach flooded, extensive Phreatic flooding	Small reduction in Aquatic I

LAKE: CARIBOU

Shoreline Type	Length (m)	Level	Lake Level Increase	Lake Level Decrease
8MI.1	3 500	0.2	No change	Aquatic I reduction (20 m)
		0.5	Increased erosion, some upland flooding	Aquatic I reduction (50 m)
		1.0	Increased erosion, upland flooding	Aquatic I reduction (100 m)
8MQI.1	2 000	0.2	Phreatic zone flooding	Aquatic I reduction (20 m)
		0.5	Extensive Phreatic zone flooding	Aquatic I reduction (50 m)
		1.0	Extensive Phreatic zone flooding	Aquatic I reduction (100 m)
8QMI.1	3 500	0.2	Phreatic zone flooding	Aquatic I reduction (20 m)
		0.5	Extensive Phreatic zone flooding	Aquatic I reduction (50 m)
		1.0	Extensive Phreatic zone flooding	Aquatic I reduction (100 m)
8FQI.1	2 000	0.2	Phreatic zone flooding	Aquatic I reduction (20 m)
		0.5	Extensive Phreatic zone flooding	Aquatic I reduction (50 m)
		1.0	Extensive Phreatic zone flooding	Aquatic I reduction (100 m)
8QI.1	2 800	1.0	Phreatic zone flooding	Aquatic I reduction (20 m)
		0.5	Extensive Phreatic zone flooding	Aquatic I reduction (50 m)
		1.0	Extensive Phreatic zone flooding	Aquatic I reduction (100 m)

LAKE: ETHEL

Shoreline Type	Length (m)	Level	Lake Level Increase	Lake Level Decrease
BFQ1.1	300	0.2	Lake margin (beach) decrease	Ice scour decrease
		0.5	Phreatic decrease (30 m)	Emergent decrease
		1.0	Phreatic decrease (70 m)	Emergent decrease (50 m)
BM3.1	350	0.2	Some beach flooding	No change
		0.5	Extensive beach flooding	Beach increase
		1.0	Extensive beach flooding	Extensive beach increase
BM3.2	700	0.2	No change	Ice scour increase (10 m)
BM3.3	1 000	0.5	Some increased erosion	Ice scour decrease (25 m)
		1.0	Erosion increase, some upland flooding of agricultural areas	Ice scour increase (50 m) Emergent eliminated, Aquatic I decrease
BM3.4	500	0.2	Increased erosion	Emergent zone reduction (10 m)
		0.5	Increased erosion, some upland flooding	Emergent zone eliminated, some Aquatic I reduction
		1.0	Increased erosion, upland flooding	Emergent zone eliminated, Aquatic I eliminated or sharply reduced
BM3.5	1 700	0.2	Increased erosion	Increased ice scour
		0.5	Increased erosion	Decreased emergent
		1.0	Increased erosion	Emergent eliminated

LAKE: ETHEL

Shoreline Type	Length (m)	Level	Lake Level Increase	Lake Level Decrease
8M4.1	700	0.2	Increased erosion	Decreased emergent, increased ice scour
		0.5	Increased erosion	Eliminated emergent, increased ice scour
		1.0	Increased erosion	Aquatic and emergent eliminated
8MQ1.1	800	0.2	Increased erosion	Emergent reduced (20 m)
		0.5	Increased erosion	Emergent eliminated, Aquatic I reduced
		1.0	Upland flooding	Emergent, Aquatic I eliminated, Aquatic II reduced
8MQ1.2	1 000	0.2	Phreatic reduced	Emergent eliminated
		0.5	Phreatic eliminated	Aquatic II reduced
		1.0	Upland flooding, Phreatic eliminated	Aquatic II reduced
8MQ1.3	50	0.2	Phreatic decrease (20 m)	Emergent eliminated
		0.5	Phreatic decrease (50 m)	Emergent eliminated, Aquatic reduced
		1.0	Phreatic decrease (100 m)	Emergent eliminated, Aquatic reduced
8FQ1.1	2 400	0.2	No change	
		0.5	Extensive flooding of Phreatic zone (50 m)	
		1.0	Extensive flooding of Phreatic zone (100 + m)	

LAKE: Long Bay, Cold Lake

Shoreline Type	Length (m)	Level	Lake Level Increase	Lake Level Decrease
8FQ1.1	1 500	0.2	Phreatic zone decrease (20 m)	Emergent zone decrease (5 m)
8M7.1	4 000	0.5	Phreatic zone decrease (50 m) to eliminated	Emergent zone decrease (10 m)
8M7.2	4 500	0.5	Phreatic zone decrease (50 m) to eliminated	Emergent zone decrease (10 m)
8M8.1	4 500	1.0	Phreatic zone reduced (100-200 m)	Aquatic species compositional change

LAKE: MANATOKAN

Shoreline Type	Length (m)	Level	Lake Level Increase	Lake Level Decrease
8A1.1	500	0.2	Some flooding of Phreatic zone (20 m)	Reduction of Aquatic I zone
8F1.1	700			
8G1.1	1 300			
8M1.4	6 500	0.5	Extensive flooding of Phreatic zone (50 + m)	Extensive reduction or elimination of Aquatic I and Emergent zone
		1.0	Extensive flooding of Phreatic zone	Elimination of Aquatic I and Emergent zone
8M1.1	1 000	0.2	No change	Reduction (20 m) of Emergent zone
8M1.2	300			
8M1.3	600	0.5	Some increased erosion and fallen trees	Elimination of Emergent zone
8M1.5	500	1.0	Some increased erosion and fallen trees	Elimination of Emergent zone

LAKE: MARIE

Shoreline Type	Length (m)	Level	Lake Level Increase	Lake Level Decrease
8F1.1	1 800	0.2	Lake margin decrease 2-3 m	Beach increase 2 m
		0.5	Lake margin elimination (no more beach), upland bank erosion	
		1.0	No beach, upland bank erosion, some falling trees	Beach increase 10 m
8FQ1.1	1 000	0.2	Margin (beach) decrease 1 m	Margin widens
		0.5	Beach disappears	Margin widens 50 m, sand beach
		1.0	Beach zone, Phreatic narrows, willows die, increased erosion	Margin widens 100 m, sand beach
8LM1.1	500	0.2	Decrease in Emergent zone	Narrowing Aquatic
		0.5	Elimination of Emergent zone, some harrowing of Phreatic, loss of willow	Aquatic I zone decrease by 70 m (50%)
		1.0	Elimination of Emergent zone, decrease of Phreatic, loss of willow, some die-off of trees in upland	Elimination of Aquatic zone
8M2.1	10 000	0.2	No change	Margin wider
		0.5	Aquatic I increase, margin armouring overtopped, erosion, falling trees	
		1.0	Erosion, many falling trees	Margin widens 25 m, sand beach, Aquatic decrease, loss of Aquatic plants

LAKE: MARIE

Shoreline Type	Length (m)	Level	Lake Level Increase	Lake Level Decrease
BM3.1	2 000	0.2	Little change, erosion in storms	Little change
		0.5	Erosion above armouring, upland bank decrease	Margin widens, sand beach 10 m
		1.0	Heavy erosion, some falling trees	Margin widens, beach 25 m
BM3.2	2 000	0.2	No change	Some expansion of the Ice Push zone
BM3.3	500	0.5	Increased flooding of the Phreatic zone, gradual elimination or replacement of the Ice Push zone	Reduction of the Emergent zone (25-30 m), expansion of the Ice Push zone
		1.0	Increased flooding of the Phreatic zone, elimination or replacement of the Ice Push zone, reduction in Aquatic I habitat	Heavy reduction of the Emergent zone (50 + m), some species changes in the Aquatic I zone
BMF2.1	600	0.2	No change	No change
		0.5	Upland Bank I flooded, increased erosion, some fallen trees	Increased sandy beach (20 m)
		1.0	Upland Bank I flooded, increased erosion, fallen trees	Increased sandy beach (20 m)

LAKE: MAY

Shoreline	Length (m)	Level	Lake Level Increase	Lake Level Decrease
8FQ1.1	2 400	0.2	Some flooding of Phreatic zone	Some reduction (20 m) of Aquatic I
		0.5	Extensive flooding of Phreatic zone	Extensive reduction of Aquatic I (50 m)
		1.0	Extensive flooding of Phreatic zone	Extensive reduction of Aquatic I (100 m)
8M1.1	3 000	0.2	No change	No change
8MF1.1	700	0.5	Increased erosion, some fallen trees	Increased beach
		1.0	Increased erosion, fallen trees	Increased beach
8M1.2	1 000	0.2	No change	Some restrictions of Emergent zone
		0.5	Increased erosion, some fallen trees	Emergent zone severely restricted (40-50 m)
		1.0	Increased erosion, fallen trees	Emergent zone eliminated
8M1.3	500	0.2	Some flooding of sandy beach (10 m)	Aquatic beds restricted (5-10 m)
		0.5	Sandy beach eliminated, some erosion	Aquatic beds very restricted (20-30 m)
		1.0	Extensive erosion, fallen trees	Aquatic beds eliminated
8MF1.2	45	0.2	Extensive erosion, fallen trees	Emergent bed restricted (20 m)
		0.5	Extensive erosion, fallen trees	Emergent bed eliminated
		1.0	Extensive erosion, fallen trees	Aquatic bed severely restricted, Emergent bed eliminated

LAKE: MOOSE

Shoreline Type	Length (m)	Level	Lake Level Increase	Lake Level Decrease
8G1.1	19 300	0.2	Some erosion of upland	Restriction of Emergent I zone
		0.5	Reduction of Emergent II and elimination of Emergent I. Some erosion, falling trees	Emergent I eliminated, Emergent II reduced by 30-50 m
		1.0	Reduction of Emergent II by up to 200 m, Emergent I eliminated. Erosion, falling trees	Emergent I eliminated, Emergent II reduced by 100 + m. Species change or restriction of Aquatic I
8G1.2	4 000	0.2	Beach eliminated	Little change
		0.5	Beach eliminated, erosion of bank, falling trees	Aquatic I reduced
		1.0	Beach eliminated, severe erosion, falling trees	Aquatic I reduced by 10 m
8G1.3	1 400	0.2	Little change	Little change
		0.5	Lake margin flooded, erosion of sandy upland bank	Beach could widen by several metres at low lake level
		1.0	Erosion of upland bank	Beach development of up to 20 m, Aquatic I reduced by 20 m
8G1.4	3 600	0.2	Beach eliminated	Decrease of Emergent I
		0.5	Beach eliminated, Emergent decrease, erosion of bank	Beach widens but could be muddy, decrease of Emergent I

LAKE: MOOSE

Shoreline Type	Length (m)	Level	Lake Level Increase	Lake Level Decrease
8G1.4 (cont.)	3 600	1.0	Emergent eliminated, erosion of bank, dead and falling trees	Emergent eliminated, beach widens but could be muddy
8G1.5	4 000	0.2	Erosion, dead and falling trees	Little change
		0.5	Erosion, dead and falling trees	Emergent reduced by 20 m
		1.0	Erosion, dead and falling trees, Emergent reduced	Emergent reduced by 40 m
8G1.6	600	0.2	Little change	Slight reduction in Aquatic I
		0.5	Erosion of upland bank, Aquatic I reduced	Aquatic I reduced by 40 m
		1.0	Severe erosion, falling trees, Aquatic I reduced by up to 60 m	Aquatic I reduced by 60 m
8M3.1	7 500	0.2	Slight erosion, falling trees	Little change
		0.5	Erosion, falling trees, Aquatic I reduced	Aquatic I reduced by 20 m
		1.0	Erosion severe, falling trees, Aquatic I reduced by 50 m	Aquatic I reduced by 50 m
8M3.2	400	0.2	Some erosion of bank	Little change
		0.5	Erosion of bank, willows could die if high water is prolonged	Decrease of Aquatic I

LAKE: MOOSE

Shoreline Type	Length (m)	Level	Lake Level Increase	Lake Level Decrease
8M3.2 (cont.)	400	1.0	Erosion of bank, willow die-off	Decrease of Aquatic I and II. Some species change likely
8M3.3	2 000	0.2	Beach eliminated, some erosion	Beach widened by 10 m
		0.5	Beach eliminated, erosion, falling trees	Beach widened by 20 + m, Aquatic I reduced
		1.0	Severe erosion, falling trees	Beach up to 50 m wide, Aquatic I reduced
8M3.4	800	0.2	Beach decrease by half	Beach increase
		0.5	Beach eliminated	Beach increase by 30 m, Aquatic I decrease
		1.0	Beach eliminated, upland flooded, cottages threatened, especially in storms, trees die-off	Beach increase by 60 m, Aquatic I eliminated
8M3.5	600	0.2	Slight erosion	Little change
		0.5	Erosion of upland bank, margin eliminated, some aspens falling	Emergent decrease by 80 m
		1.0	Erosion, falling trees	Emergent eliminated
8M6.1	450	0.2	Upland bank, some erosion and leaning trees, Margin eliminated, Aquatic I reduced slightly, Aquatic II no change	Upland bank no change, Margin no change, Aquatic I reduced 5 m, Aquatic II no change,
		0.5	Upland bank flooded in by up to 1 m. Erosion, falling trees, Margin eliminated, Aquatic I reduced by 10 m, Aquatic II reduced slightly	Upland bank no change, Margin no change, Aquatic I reduced 8 m, Aquatic II no change

LAKE: MOOSE

Shoreline Type	Length (m)	Level	Lake Level Increase	Lake Level Decrease
8M6.1 (cont.)	450	1.0	Upland bank flooded in by up to 2 m. Severe erosion, falling trees. Margin eliminated, Aquatic I reduced by 15 m, Aquatic II reduced slightly	Upland bank no change, Margin no change, Aquatic I reduced by 15 m, Margin no change, Aquatic I reduced by 15 m, Aquatic I reduced by 15 m, Aquatic II no change
8M6.2	500	0.2	Some reduction of Typha in Phreatic I	Slight reduction of Aquatic I
		0.5	Reduction of Typha in Phreatic I, long duration of high water could eliminate it	Reduction of Typha, reduction of Aquatic I by up to 25 m
		1.0	Typha in Phreatic I eliminated, some die-off of willows in Phreatic II	Elimination of Typha in Phreatic I, Aquatic I reduced by 30 m
8M6.3	1 600	0.2	No change	Little change
		0.5	Increased erosion of upland bank, leaning trees	Slight reduction of Aquatic I, up to 5 m of sand beach could appear at low lake level
		1.0	Upland bank flooded, severe erosion, falling trees	Reduction of Aquatic I, up to 10 m of sand beach could appear
8M6.4	300	0.2	Beach eliminated	Beach increased by 4 m
		0.5	Beach eliminated, upland bank flooded, some erosion	Beach increased by 10 m to 25 m
		1.0	Beach eliminated, upland bank completely flooded, flooding into the upland, die-off of trees	Beach increased by 50 m

LAKE: MOOSE

Shoreline Type	Length (m)	Level	Lake Level Increase	Lake Level Decrease
8M6.5	200	0.2	Beach eliminated, Phreatic reduced	Beach increased by up to 4 m at low lake level
		0.5	Beach eliminated, Phreatic eliminated	Beach increased by up to 10 m, Aquatic I reduced by 10 m
		1.0	Beach eliminated, Phreatic eliminated, flooding of upland bank	Beach increased by 20-30 m, Aquatic reduced by 20-30 m
8M6.6	2 400	0.2	Erosion, falling trees	Little change
		0.5	Erosion, falling trees	Aquatic I decrease by 15 m
		1.0	Severe erosion, falling trees, turbidity increase	Aquatic I decrease by up to 40 m. Some sand beach could appear at low lake levels
8M6.7	3 500	0.2	Little change	Little change
		0.5	Lake margin flooded, erosion of upland bank, falling trees	Emergent reduced by up to 3 m, ice scour could increase
		1.0	Erosion, falling trees, Emergent reduced	Emergent reduced by up to 6 m, ice scour zone could increase
8MF2.1	500	0.2	Beach eliminated	Beach increase by 2 m, might be muddy
		0.5	Beach eliminated. Flooding into upland bank	Beach increase by 10 m could be muddy
		1.0	Beach eliminated, flooding into upland bank, erosion, dead and falling trees	Beach increase by 25 m, could be muddy. Aquatic I decrease by 25 m

LAKE: MOOSE

Shoreline Type	Length (m)	Level	Lake Level Increase	Lake Level Decrease
8Q1.1	2 800	0.2	Little change	Little change
		0.5	Emergent I eliminated, Emergent II reduced, flooding into Phreatic	Emergent I eliminated, Emergent II reduced by 30 to 100 m. Aquatic I reduced
		1.0	Emergent I eliminated, Emergent II reduced by 60 to 200 m. Phreatic flooded by up to 100 m, death of willows, etc., if flooding is prolonged	Emergent I eliminated, Emergent II reduced by 60 to 200 m. Aquatic I reduced by 500 m
8Q1.2	800	0.2	Sand beach eliminated	Beach increase
		0.5	Beach eliminated, erosion of upland bank, dead and falling trees	Beach increase of 25 m, decrease of Aquatic I
		1.0	Beach eliminated, erosion, dead and falling trees	Beach increase of 50 m, decrease of Aquatic I
8QF1.1	200	0.2	Little change	Little change
		0.5	Emergent zone reduced, ice scour zone increases	Emergent zones reduced, ice scour increased, Aquatic I reduced
		1.0	Emergent eliminated, ice scour zone increased, some die-off of birch, willow	Emergent eliminated, ice scour zone increased, Aquatic I reduced by 70 + m

LAKE: MURIEL

Shoreline Type	Length (m)	Level	Lake Level Increase	Lake Level Decrease
8M5.1 (cont.)	3 000	1.0	Erosion, falling trees, ice scour zone increase, Emergent eliminated, Aquatic I reduced	Ice scour zone increase, Emergent eliminated, Aquatic zones reduced
8M5.2	1 100		Same as 8M5.1 except for flooding of beach	Same as 8M5.1 except for widening of beach
8M5.3	2 000	0.2	Little change	Little change
		0.5	Aquatic I reduced, erosion of sandy bank	Beach becomes muddy, Aquatic I reduced
		1.0	Aquatic I reduced, erosion of banks, dying trees, falling trees	Muddy shore, Aquatic I reduced
8M6.1	1 300	0.2	Little change	Little change
		0.5	Emergent reduced, Aquatic I reduced or species change, flooding of upland (hay)	Emergent reduced, Aquatic I reduced
		1.0	Emergent eliminated, Aquatic I reduced, upland flooded (hay)	Emergent eliminated, Aquatic I reduced
8M7.1	9 500	0.2	Little change	Little change
		0.5	Erosion of upland, falling trees, Emergent reduced	Emergent eliminated, possible species change in Aquatic I
		1.0	Erosion of upland, falling trees, Emergent eliminated, Aquatic I reduced	Emergent eliminated, Aquatic I reduced

LAKE: MURIEL

Shoreline Type	Length (m)	Level	Lake Level Increase	Lake Level Decrease
8M7.2	300	0.2	Beach reduced by 1-4 m	Beach widens by 4 m
		0.5	Beach reduced by 2-10 m	Beach widened by 10 m, muddy beach, Aquatic I reduced
		1.0	Beach eliminated, trees die, cottages flooded	Mud shore of 20 m between beach and water, Aquatic I reduced
8M7.4	2 000		Similar to 8Q1.1	Similar to 8Q1.1
8M7.5	2 000	0.2	Species change in Emergent	Possible species change in Aquatic I
		0.5	Emergent eliminated, species change in Aquatic I	Emergent eliminated, Aquatic I possibly eliminated or severe species change
		1.0	As above	Emergent eliminated, Aquatic I eliminated
8M7.6	250	0.2	Little change	Little change
		0.5	Emergent reduced, Aquatic I reduced	Emergent reduced, Aquatic I reduced
		1.0	Emergent eliminated, Aquatic I reduced, species change	Emergent eliminated, Aquatic I reduced
8M9.1	2 000	0.2	Some erosion	Little change
		0.5	Erosion, falling trees	Cobtle margin increase
		1.0	Severe erosion, falling trees	Cobble margin increase

LAKE: MURIEL

Shcreline Type	Length (m)	Level	Lake Level Increase	Lake Level Decrease
8M9.2	4 500	0.2	Similar to 8M9.1	Little change
		0.5	Similar to 8M9.1	Mud exposed along shore
		1.0	Similar to 8M9.1	Mud exposed along shore
8MF1.1	1 000	0.2	Little change	Little change
		0.5	Beach reduced by 3 m	Mud margin between beach and water
		1.0	Beach eliminated. Cottages flooded especially in storm events	Mud margin up to 15 m between beach and water. Aquatic I reduced
8ML1.1	500	0.2	Phreatic narrowed slightly, willows could die if high water prolonged	Little change
		0.5	Could eliminate Phreatic, aspen die-off, Emergent reduced, species change in Aquatic I	Aquatic I narrowed by 50 m, Scirpus reduced
		1.0	Die off of aspen, some falling trees, eliminate Phreatic, eliminate Emergent, species change in Aquatic I	Aquatic reduced 100 m, Scirpus eliminated
8ML1.2	600	0.2	Beach reduced or eliminated	Little change
		0.5	Beach eliminated, erosion of bank, falling trees, Aquatic I reduced	Beach increase 2 + m, Aquatic I reduced 20 m

LAKE: MURIEL

Shoreline Type	Length (m)	Level	Lake Level Increase	Lake Level Decrease
8ML1.2 (cont.)	600	1.0	Beach eliminated, erosion severe, falling trees, Aquatic I reduced up to 100 m	Beach increase up to 50 m, Aquatic I reduced 75 m
8ML1.3	4 200		Similar to 8ML1.2	Similar to 8ML1.2
8MQ1.1	2 000	0.2	Little change	Little change
		0.5	Erosion, ice scour zone could increase, reduction of Aquatic I, reduction of Emergent I	Ice scour zone increase, reduction of Aquatic I, reduction of Emergent I
		1.0	Erosion, falling trees, emergent eliminated, Aquatic I reduced	Ice scour zone could increase, Emergent I reduced, Aquatic I reduced
8Q1.1	500	0.2	Possible species change or reduction of Emergent I and Emergent II	Species change in Emergent II
		0.5	Reduction of Emergent I, loss of Carex possible, die-off of trees in Phreatic	Reduction of Emergent II, species change in Emergent I, reduction of Aquatic I
		1.0	Elimination of Emergents, reduction of Aquatic I, dead and falling trees	Elimination of Emergent II, species change and reduction of Emergent II, reduction of Aquatic I

LAKE: REITA

Shoreline Type	Length (m)	Level	Lake Level Increase	Lake Level Decrease
8FQ1.1	3 000	0.2	Some flooding of the Phreatic zone	Restriction of the Aquatic zone (20 m)
		0.5	Extensive flooding of the Phreatic zone (50 m)	Severe restriction of the Aquatic zone (100 + m)
		1.0	Extensive flooding of the Phreatic zone (100 + m)	Elimination of the existing Aquatic zone (150 + m)
8M4.1	5 500	0.2	No change	No change
		0.5	No change	Small restriction of Aquatic beds (10 m)
		1.0	No change	Restriction of Aquatic bed (50 m)
8MQ1.1	6 000	0.2	Some flooding (20 m) of Phreatic zone	Some (10 m) desiccation of Phreatic zone, reduction (20 m) of Emergent zone
		0.5	Extensive flooding of Phreatic zone (50 m)	Extensive desiccation of Phreatic zone, reduction or elimination (50 m) of Emergent zone
		1.0	Extensive flooding or elimination of Phreatic zone	Extensive desiccation of Phreatic zone, reduction or elimination of Emergent zone and Aquatic zone
8MQ1.2 8MQ1.3 8MQ1.4	3 100 1 900 400	0.2	No change	Some (10 m) desiccation of Phreatic zone, reduction (20 m) of Emergent zone

LAKE: REITA

Shoreline Type	Length (m)	Level	Lake Level Increase	Lake Level Decrease
8MQ1.2 (cont.)	3 100	0.5	Increased erosion, some fallen trees	Extensive desiccation of Phreatic zone, reduction or elimination of Emergent zone and Aquatic zone
8MQ1.3	1 900			
8MQ1.4	400			
		1.0	Increased erosion, fallen trees	Extensive desiccation of Phreatic zone, reduction or elimination of Emergent zone and Aquatic zone

LAKE: TUCKER

Shoreline Type	Length (m)	Level	Lake Level Increase	Lake Level Decrease
8A1.1 8FQ1.1 8F2.1 8F2.2 8M2.1 8M4.1 8A1.2	4 000 600 1 100 300 1 500 1 000 500	0.2	Some increased erosion and fallen trees	Increased ice scour zone, some restriction of Emergent zone
		0.5	Extensive increased erosion and fallen trees	Increased ice scour zone, elimination of Emergent zone
		1.0	Extensive increased erosion and fallen trees	Increased ice scour zone, elimination of Emergent zone
		0.2	Some increased erosion	Some increase in sandy beach
		0.5	Extensive increased erosion, some flooding	Some increase in sandy beach (30 m)
		1.0	Extensive increased erosion, some flooding	Extensive (60 m) increase in sandy and silty beach
8Q1.1 8M3.1 8LQ1.1	1 500 1 100 500	0.2	Emergent zone increase (20 m)	Phreatic zone increase, elimination of Emergent II
		0.5	Emergent zone increase, elimination of tamarack	Phreatic zone increase, elimination of Emergent II, 50 m reduction in Emergent I
		1.0	Emergent zone increase, potential elimination of Phreatic zone	Phreatic zone increase, elimination of Emergent I and II

LAKE: WOLF

Shoreline Type	Length (m)	Level	Lake Level Increase	Lake Level Decrease
8F1.1	150	0.2	Sand beach decreased in area	Sand beach increased in area
		0.5	Sand beach eliminated	Sand beach increased (less than 10 m)
		1.0	Sand beach eliminated, erosion of shoreline	Sand beach extensively increased (more than 10 m)
8F1.2	5 000	0.2-1.0	Same as 8F1.1	Same as 8F1.1
8F1.3	1 850	0.2	No change	Emergent zone decrease (less than 10 m)
		0.5	Increased erosion and fallen trees	Emergent zone decreased (greater than 10 m) with an increased ice scour zone
		1.0	Increased erosion and fallen trees, elimination of Emergent zone	Elimination of present Emergent zone, increased ice scour zone
8F3.1	550	0.2	No change	Increased ice scour zone
		0.5	Increased erosion and fallen trees	Emergent zone decreased by 50 m. Ice scour zone increased
		1.0	As abcve	As above
8M2.1	5 500	0.2	No change	No change
		0.5	Increased erosion and fallen trees	Increased lake margin
		1.0	As above	As above

LAKE: WOLF

Shoreline Type	Length (m)	Level	Lake Level Increase	Lake Level Decrease
8M4.1	4 000	0.2	No change	Lake margin increase
		0.5	Increased erosion and fallen trees	Increased lake margin, decreased Aquatic zone (less than 10 m)
		1.0	Increased erosion and fallen trees	Increased lake margin and decreased Aquatic zone (more than 10 m)
8M4.2	1 050	0.2	No change	Lake margin increase
		0.5	Increased erosion and fallen trees	Lake margin increase, decreased Emergent zone (less than 10 m)
		1.0	Increased erosion and fallen trees	Lake margin increased, Emergent zone eliminated
8M4.3	4 450	0.2-1.0	Same as 8M4.2	Same as 8M4.2
8M4.4	2 300	0.2	No change	Decreased Emergent zone (less than 10 m)
		0.5	No change	Emergent zone eliminated, Aquatic I zone decreased
		1.0	Phreatic species change	Phreatic zone eliminated and species change, Emergent zone eliminated, Aquatic I decreased (by greater than 10 m)

LAKE: WOLF

Shoreline Type	Length (m)	Level	Lake Level Increase	Lake Level Decrease
8M4.5	600	0.2	No change	Emergent zone decreased (by less than 10 m)
		0.5	Emergent zone decreased, Aquatic I zone increased	Emergent zone decreased (by less than 10 m)
		1.0	Aquatic I zone increased, Emergent zone decreased	Emergent zone decreased extremely (greater than 10 m) or eliminated
8M4.6	1 650	0.2	Increased erosion and fallen trees	No change
		0.5	Increased erosion and fallen trees	Emergent zone decreased
		1.0	Increased erosion and fallen trees	Emergent zone decreased
8M4.7	5 000		Same as 8M4.1	Same as 8M4.1
8M4.8	300	0.2	No change	No change
		0.5	Increased erosion and fallen trees	Increased ice scour, decreased Emergent zone
		1.0	Marked increased erosion and fallen trees	Increased ice scour, decreased Emergent zone
8MQ1.1	1 750	0.2	Decreased Phreatic zone	No change
		0.5	Decreased Phreatic zone	Decreaded Aquatic I zone
		1.0	Eliminated or sharply decreased Phreatic zone	Decreased Aquatic I zone

LAKE: WOLF

Shoreline Type	Length	Level	Lake Level Increase	Lake Level Decrease
8MQ1.2	1 700	0.2-1.0	Same as 8M4.1	Same as 8M4.1
8MQ1.3	3 600	0.2	Decreased Phreatic zone	Decreased Emergent zone
		0.5-1.0	Marked decrease in Phreatic zone	Marked decrease in Emergent zone (greater than .0 m)
8MQ1.4	1 750	0.2	No change	Ice scour increased, emergent zone decreased
		0.5	Increased erosion and fallen trees	Ice scour increased, Emergent zone decreased
		1.0	As above	Marked increase in ice scour zone, marked decrease in Emergent zone (greater than 10 m)
8MQ2.1	3 500	0.2-1.0	Marked decrease in Phreatic zone	Marked increase in ice scour, marked decrease in Emergent zone (greater than 10 m)
8MQ2.2	400	0.2-1.0	Same as 8Q2.1	Same as 8Q2.1

Appendix IV

Responses of Plant Species in the Cold Lake Region to Changes in the Water Table

A Set of Predictive Matrices Based on a Review of the Literature

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Classification of Habitats

Habitats are defined in the terms of reference on the basis of soil moisture and erosional status. These criteria are rarely given explicitly in the literature, so here we give the characteristics that were used to place sites from the literature into the habitat classification.

Upland - habitats in which the water table is at or below the soil surface for the entire year. Included here are forests, spruce and heath bogs, larch fens and mesic meadows (with Calamogrostis spp.).

Upland Bank - habitats may be eroded by wave action but are not subjected to flooding. Stream and river levees were placed in this category.

Phreatic - habitats are regularly subjected to flooding in spring, but the water table is at or below the soil surface in August of most years. Lake margin habitats are subject to the same sequence of moisture changes and were lumped into this category in the matrices.

Emergent - habitats are covered by less than 50 cm of water for the entire growing season. It is notable that most of the species normally classed as emergent are not capable of tolerating permanent submergence at the deeper end of the range at water depths.

Ice Push - habitats occur where sediments are deposited by ice action. The closest analogy in the literature is alluvial fans.

Ice Scour - habitats are dominated by irregular erosion due to ice movement, which removes rhizomes and other buried plant parts. The analogous habitat from the literature is eroded gullies around lake margins. NOTE that ice push and ice scour habitats are not defined by flooding but by physical disturbance. Characteristic species persist by rhizomes and invade by seeds, vegetative expansion and deposition of vegetative propagules.

Aquatic 1 - habitats permanently submerged from 0.5-1.0 m

Aquatic 2 - habitats permanently submerged from 1.0-2.0 m

Aquatic 3 - habitats permanently submerged from 2.0 + m.

Use of Matrices

Data for each species are arranged in a 9 x 9 matrix, in which the columns correspond to the initial habitat state prior to alteration of water levels (S_1), and the rows give the change in environment brought about by raising (moving downward in the matrix) or lowering (moving upward in the matrix) water elevation (S_1).

1. There are five possible principal entries for each element of the matrix:

NC = no change, species unaffected by alteration or absent from both S_o and S_1

I = an increaser (in cover or relative importance)

D = a decreaser
V = an invader
E = eliminated

All matrix entries are based on the assumption that habitat S_0 is permanently converted to habitat S_1. If this is not the case and water levels fluctuate considerably, response rates will need to be used to infer the degree of resonse (see below).

2. The source of the information on which the principal entry is based is shown as an exponent, i.e. NC^{15} means that supporting information will be found in reference 15.

Where "s" appears as the exponent, the entry is speculative, based on affinity to species whose responses are known.

Where "u" appears as the exponent, the entry is based on unpublished observations of the authors.

Information Gaps

There are a number of species included in the terms of reference for which there is no published information on soil moisture requirements and tolerances, or which are not explicitly mentioned as components of the vegetation when patterns are described. These species are listed below, and their closest ecological equivalents for which there is good information are indicated.

Species	Ecological Equivalent
Alnus crispa	Salix discolor
Actaea rubra	Ribes spp.
Prunus virginiana	Rosa acicularis
Vaccinium myrtilloides	Picea mariana
Cornus canadensis	Picea glauca
Rubus pedatus	Picea glauca
Petasites palmatus	Picea glauca
Epilobium sp.	Rosa acicularis
Equisetum sylvaticum	Picea glauca
Arctostaphylos uva-ursi	Pinus banksiana
Utricularia vulgaris	Myriophyllum exalbescens
Myriophyllum spicatum	Myriophyllum exalbescens
Cicuta sp.	Calamogrostis inexpansa
Eriophorum sp.	Carex atherodes
Elymus innovatus	Rosa acicularis
Bromus inermis	Rosa acicularis
Mosses	?

3. The rate at which a response occurs is shown by an unbracketed subscript, below and to the right of the principal entry:

f = fast, within the same growing season
m = medium within 2-5 years
s = slow, greater than 5 years for response
vs = very slow, 25 years or more for response

Note that the rates shown are times required for the response to reach a steady state. If habitat conditions fluctuate, the response of a species will depend on its rate of response, i.e. if a shrub is slowly eliminated by conversion of an upland to a phreatic habitat, but the flooding producing the phreatic habitat only occurs for 2 years, then the species would decrease rather than be eliminated over that time period.

4. The mode of change is shown in parentheses following the principal entry:

s = invasion or replacement by seeds
v = invasion or replacement by vegetative means; tillers, runners or rhizomes
w = decrease or elimination because of desiccation
e = decrease or elimination because of erosion of parts
c = decrease or elimination because of competition

5. In addition, some species have been found to be hightly sensitive to the timing of changes in water regime, and life stages may respond differently from one another. In these cases, this information is given in parentheses following the principal entry.

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SPECIES: Abies balsamea- an upland species in mature mesic forests.

S_0 (INITIAL STATE)

S_t (FINAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND	☒	V_s^{27} (v+s)	→	→	→	→	→	→	→
UPLAND BANK	NC	☒	NC	NC	V_s^{27}	→	→	→	→
ICE PUSH	D_s^s	NC	☒	NC	V_s^s	→	→	→	→
ICE SCOUR	"	"	NC	☒	V_s^s	→	→	→	→
PHREATIC	D_m^1	E_m^1 (old trees) D_s (1-2' trees)	→	→	☒	NC	→	→	→
EMERGENT	E_f^1	→	→	→	NC	☒	NC	→	→
AQUATIC 1	E_f^1	→	→	→	NC	→	☒	NC	NC
AQUATIC 2	"	→	→	→	NC	→	→	☒	NC
AQUATIC 3	"	→	→	→	NC	→	→		☒

SPECIES: Alnus tenuifolia- an upland species around the margins of lakes and streams.

S_0 (INITIAL STATE)

S_t (FINAL STATE)

	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND		D_s^U	→	→	I_s^s	$V_s^{27,35}$ (s)	→	→	→
UPLAND BANK	I_s^u		NC	NC	I_s^s	$V_s^{27,35}$	→	→	→
ICE PUSH	V_s^7	NC		NC	V_s^7	→	→	→	→
ICE SCOUR	"	"	NC		V_s^7	→	→	→	→
PHREATIC	D_m^s	→	→	→		V_s^s	→	→	→
EMERGENT	E_f^s	→	→	→	→		NC	→	→
AQUATIC 1	"	→	→	→	→	NC		NC	NC
AQUATIC 2	"	→	→	→	→	NC	NC		NC
AQUATIC 3	"	→	→	→	→	NC	→	→	

SPECIES: Amelenchier alnifolia- an upland species of open, mostly deciduous forests.

S_0 (INITIAL STATE)

S_t (FINAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND		NC	V_m^7 (v+s)	→	→	→	V_s^7	→	→
UPLAND BANK	D_m^s		"	→	→	→	"	→	→
ICE PUSH	D_m^7	NC		NC	V_s^7 (s)	→	→	→	→
ICE SCOUR	"	"	NC		V_s^7 (s)	→	→	→	→
PHREATIC	E_m^7 (w.t.< 30cm in Aug)	→	→	→		NC	→	→	→
EMERGENT	E_f^s	→	→	→	NC		NC	→	→
AQUATIC 1	"	→	→	→	NC →	→		NC →	→
AQUATIC 2	"	→	→	→	NC →	→	→		NC
AQUATIC 3	"	→	→	→	NC →	→	→	→	

SPECIES: *Aralia nudicaulis*- an upland shrub under dense spruce and moist aspen forests.

S_0 (INITIAL STATE)

S_t (FINAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND		NC	V_m^7	→	→	→	V_s^s	→	→
UPLAND BANK	D_f^s		NC	NC	V_m^7 →	→	V_s^s	→	→
ICE PUSH	E_f^7	E_f^7		NC	NC	→	→	→	→
ICE SCOUR	E_f^7	E_f^7	NC		NC	→	→	→	→
PHREATIC	E_m^7	E_m^7	NC	NC		NC	→	→	→
EMERGENT	E_f^7	E_f^7	NC	→	→		NC	→	→
AQUATIC 1	"	"	NC	→	→	→		NC →	→
AQUATIC 2	"	"	NC	→	→	→	→		NC
AQUATIC 3	"	"	NC	→	→	→	→	→	

SPECIES: Betula glandulifera (= B. pumila)- a phreatic species of ombrotrophic fens.

S_0 (INITIAL STATE)

S_t (FINAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND	☒	E_m^s	NC	NC	E_s^7	NC	NC	NC	NC
UPLAND BANK	NC	☒	NC	NC	"	NC	→	→	→
ICE PUSH	NC	NC	☒	NC	D_s^s	V_m^u	V_s^s	→	→
ICE SCOUR	NC	NC	NC	☒	"	V_s^s	→	→	→
PHREATIC	V_m^7 (s+v)	I_m^7	V_m^s	V_m^s	☒	"	→	→	→
EMERGENT	E_f^7	→	→	→	→	☒	NC	→	→
AQUATIC 1	E_f^s	→	→	→	→		☒	NC →	→
AQUATIC 2	"	→	→	→	→	NC	NC	☒	NC
AQUATIC 3	"	→	→	→	→	NC	→	→	☒

SPECIES: *Calamogrostis inexpansa*- a marginal upland (wet meadow), lake margin species that can persist in phreatic habitats that are not flooded past the middle of June.

S_t (FINAL STATE) \ S_0 (INITIAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND		D^S_s	V^7_s (s)	V^7_s (s)	V^7_m	→			
UPLAND BANK	I^7_m (c)		NC	NC	V^S_f (v+s)	V^S_f (v+s)	→		
ICE PUSH	I^S_m (v)	NC		"	"	"	"	"	"
ICE SCOUR	"	"	NC		"	"	V^7_m (s)	→	
PHREATIC	E^{23}_f (unless dry by June)	E^{23}_f	E^{23}_f	E^{23}_f		NC	→		
EMERGENT	"	"	"	"	NC		NC	→	
AQUATIC 1	"	"	"	"	E^{23}_f	NC		NC	→
AQUATIC 2	"	"	"	"	"	"	NC		NC
AQUATIC 3	"	"	"	"	"	"	"	NC	

SPECIES: Betula occidentalis (= B. papyrifera)- a small tree of wet places in uplands (pond and stream margins, etc.)

S_t (FINAL STATE)	S_0 (INITIAL STATE) UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND		NC	D_s^{27}	D_s^{27}	$V_m^{1,7}$ (s)	$V_m^{1,7}$	$V_m^{7,27,35}$ (s)	→	→
UPLAND BANK	I_m^{27}		NC	NC	$V_f^{1,7,27}$ (s)	$V_f^{1,7,27}$ (s)	$V_m^{7,27}$ (s)	→	→
ICE PUSH	I_m^{27}	NC		NC	"	"	"	→	→
ICE SCOUR	"	"	NC		V_m^{27}	V_m^{27}	$V_m^{1,7,27}$	→	→
PHREATIC	E_f^1 (flooded more than 3 mo)	→	→	→		NC	→	→	→
EMERGENT	"	→	→	→	NC		NC	→	→
AQUATIC 1	$E_f^{1,27}$	→	→	→	NC	NC		NC →	→
AQUATIC 2	"	→	→	→	NC	→	→		NC
AQUATIC 3	"	→	→	→	NC	→	→	→	

SPECIES: Carex aquatilis- a phreatic and emergent species in minerotrophic fens.

S_0 (INITIAL STATE)

S_t (FINAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND		NC	NC	NC	$E_f^{5,22}$ (d)	$E_f^{5,22}$(d)	NC	NC	NC
UPLAND BANK	NC		NC	NC	"	"	NC	NC	NC
ICE PUSH	"	NC		"	"	"	"	"	"
ICE SCOUR	"	"	NC		"	"		"	"
PHREATIC	V_f^7 (s)	V_f^7 (s)	V_f^7 (s)	V_f^7		I_m^7 (v)	V_f^S (s)	V_f^S (s)	V_f^S (s)
EMERGENT	V_m^7 (s)	V_m^7 (s)	V_m^7 (s)	V_m^7 (s)	NC		V_m^S (s)	V_m^S (s)	V_m^S (s)
AQUATIC 1	NC	NC	NC	NC	E_f^S (r)	E_f^S (r)		NC	NC
AQUATIC 2	"	"	"	"	"	"	NC		"
AQUATIC 3	"	"	"	"	"	"	"	NC	

SPECIES: *Carex atherodes*- a phreatic species in minerotrophic fens and wet meadows; replaced by *Calamogrostis inexpansa* upon drying, and requiring overwinter flooding for elimination.

S_0 (INITIAL STATE)

S_t (FINAL STATE)

	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND		D_f(veg prop.)	D_s^8, E_m	D_s^8, E_m	E_s^{22}	NC	NC	NC	NC
UPLAND BANK	NC		D_s^8	D_s^8	D_s^B	V_s^s	"	"	"
ICE PUSH	V_s^s	V_s^s		NC	D_s^u	V_m^B	V_s^B	V_s^B	V_s^B
ICE SCOUR	"	"	NC		"	"	"	"	"
PHREATIC	V_m^7	I_s^8	I_m^{22}	I_m^{22}		V_m^u(v+s)	"$_m$	"$_m$	"$_m$
EMERGENT	E_m^8 (r,4yr)	E_m^8 (wt 12.5) cm	$E_m^{22,25}$	$E_m^{22,25}$	$E_m^{22,25}$		NC	NC	NC
AQUATIC 1	NC	NC	NC	NC	E_m^{25}	NC		NC	NC
AQUATIC 2	NC	NC	NC	NC	"	NC	NC		NC
AQUATIC 3	NC	NC	NC	NC	E_f^{25}	NC	NC	NC	

SPECIES: Ceratophyllum demersum - submerged species in deep (2.5-m) water on soft sediments.

S_0 (INITIAL STATE)

S_t (FINAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND		NC	NC	NC	NC	NC	E_f	E_f	E_f
UPLAND BANK	NC		NC	NC	NC	NC	E_f	E_f	Ef
ICE PUSH	NC	NC		NC	NC	NC	E_f	E_f	E_f
ICE SCOUR	NC	NC	NC		NC	NC	E_f	E_f	E_f
PHREATIC	NC	NC	NC	NC		NC	$E_f^{36,43,44}$	$E_f^{36,43,44}$	$E_f^{36,43,44}$
EMERGENT	NC	NC	NC	NC	NC		"	"	"
AQUATIC 1	V_s^s	V_s^s	V_s^s	V_s^s	V_f^{45}(s)	V_f^{45}(s)		$D_f^{36,43,44}$ (ice dam.)	$D_f^{36,43,44}$
AQUATIC 2	"	"	"	"	"	"	$I_f^{36,43,44}$		$D_s^{36,43,44}$
AQUATIC 3	"	"	"	"	"	"	"	$I_f^{36,43,44}$	

SPECIES: Chara spp.- a submerged species ubiquitously distributed in relation to depth.

S_0 (INITIAL STATE)

S_t (FINAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND	☒	NC	→	→	→	E^u_f	→	→	→
UPLAND BANK	NC	☒	NC	→	→	E^u_f	→	→	→
ICE PUSH	NC	NC	☒	NC →	→	E^u_f	→	→	→
ICE SCOUR	"	→	→	☒	NC	"	→	→	→
PHREATIC	"	→	→	→	☒	"	→	→	→
EMERGENT	$V^U_?$	→	→	→	→	☒	$D^{47}_?$	→	→
AQUATIC 1	"	→	→	→	→	I^s_m	☒	NC	NC
AQUATIC 2	"	→	→	→	→	"	NC	☒	NC
AQUATIC 3	"	→	→	→	→	"	"	NC	☒

SPECIES: Cornus stolonifera- an upland shrub species in mesic forest.

S_t (FINAL STATE) \ S_0 (INITIAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND	☒	NC.	$I_s^{7,27}$ (s)	$I_s^{7,27}$(s)	$V_m^{7,22}$	→	→	→	→
UPLAND BANK	NC	☒	"	"	$V_m^{7,22}$	→	→	→	→
ICE PUSH	D_m^U	D_m^U	☒	NC	"	→	→	→	→
ICE SCOUR	E_m^U	E_m^U	NC	☒	"	→	→	→	→
PHREATIC	E_s^U	E_s^U	→	→	☒	NC	→	→	→
EMERGENT	E_f^S	→	→	→	→	☒	NC	→	→
AQUATIC 1	"	→	→	→	→	NC	☒	NC	NC
AQUATIC 2	"	→	→	→	→	NC	NC	☒	NC
AQUATIC 3	"	→	→	→	→	NC	→	→	☒

SPECIES: *Fragaria virginiana*- a ubiquitous upland herb in dry sites and open forest.

S_0 (INITIAL STATE)

S_t (FINAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND	╳	NC	I_s^s	V_s^7	V_m^7	V_s^{27}	→	→	→
UPLAND BANK	NC	╳	"	"	"	→	→	→	→
ICE PUSH	D_s^s	D_s^s	╳	NC	V_m^s	→	→	→	→
ICE SCOUR	E_f^s	→	→	╳	"	→	→	→	→
PHREATIC	D_f^S	D_f^S	D_f^s	D_f^s	╳	$V_s^{7,27}$	→	→	→
EMERGENT	E_f^s	→	→	→	→	╳	NC	→	→
AQUATIC 1	"	→	→	→	→	NC	╳	NC	NC
AQUATIC 2	"	→	→	→	→	NC	NC	╳	NC
AQUATIC 3	"	→	→	→	→	NC	→	→	╳

SPECIES: *Larix laricina*- a minerotrophic fen species on marginal upland sites where w.t. is within 50 cm of surface, capable of tolerating brief (less than 1 month) shallow flooding during the growing season.

S_0 (INITIAL STATE)

S_t (FINAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND	╳	NC.	V_s^s (wt 50 cm)	V_s^s	V_s^{26}(s)	→	→	→	→
UPLAND BANK	NC	╳	NC	NC	NC	NC	NC	NC	NC
ICE PUSH	E_f^s	NC	╳	NC	NC	NC	NC	NC	NC
ICE SCOUR	"	NC	NC	╳	NC	NC	NC	NC	NC
PHREATIC	$E_m^{6,7}$	NC	$V_s^{6,26}$ (if dry ff. June)	$V_s^{6,26}$	╳	$V_s^{6,26}$ if dry ff. June	→	→	→
EMERGENT	$E_f^{6,7}$	NC	NC	NC	NC	╳	NC	NC	NC
AQUATIC 1	E_f^s	NC	NC	NC	NC	NC	╳	NC	NC
AQUATIC 2	"	"	"	"	"	"	"	╳	"
AQUATIC 3	"	"	"	"	"	"	"	"	╳

SPECIES: Ledum groenlandicum- an upland species, from bogs with w.t. 0-50 cm to mature upland spruce forests, where it is localized in moist sites. Can tolerate winter and early spring but not G.S. flooding.

S_0 (INITIAL STATE)

S_t (FINAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND	☒	V_s^s (s)	V_s^s (s)	V_s^s (s)	V_s^{26} (s)	→	→	→	→
UPLAND BANK	E_f^s	☒	NC	→	→	→	→	→	→
ICE PUSH	E_f^s	NC	☒	NC	→	→	→	→	→
ICE SCOUR	E_f^s	NC	NC	☒	NC	→	→	→	→
PHREATIC	E_m^{46}	$V_s^{s,26}$(dry ff. June)	→	→	☒	→	→	→	→
EMERGENT	E_f^s	NC	→	→	→	☒	→	→	→
AQUATIC 1	"	NC	→	→	→	→	☒	→	→
AQUATIC 2	"	NC	→	→	→	→	→	☒	→
AQUATIC 3	"	NC	→	→	→	→	→	→	☒

SPECIES: *Myriophyllum exalbescens*- a submerged species common over a wide range of depths, relies on vegetative propagation.

S_0 (INITIAL STATE)

S_t (FINAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic
UPLAND	☒	NC	—	—	→	E_f^{36}	E_f^{36}	—	→
UPLAND BANK	NC	☒	NC	—	→	"	"	—	→
ICE PUSH	NC	NC	☒	NC	→	"	"	—	→
ICE SCOUR	NC	—	→	☒	NC	"	"	—	→
PHREATIC	NC	—	—	→	☒	"	"	—	→
EMERGENT	$V_{vs}^{s,u}$(s?)	—	—	—	→	☒	D_f^{36}	(ice damage	to turions)
AQUATIC 1	"	—	—	—	→	I_f^u	☒	D_f^{36} —	→
AQUATIC 2	"	—	—	—	→	" —	→	☒	I_m^u
AQUATIC 3	"	—	—	—	→	I_m^u	NC	D_m^u	☒

SPECIES: *Nuphar variegatum*- floating leaved plant confined to shallow (less than 2 m) water.

S_t (FINAL STATE)	S_0 (INITIAL STATE) UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND	☒	NC	→	→	→	E_f^{36}	→	→	→
UPLAND BANK	NC	☒	NC	→	→	"	→	→	→
ICE PUSH	NC →	→	☒	NC →	→	"	→	→	→
ICE SCOUP	NC	→	→	☒	NC	"	→	→	→
PHREATIC	NC	→	→	→	☒	"	→	→	→
EMERGENT	V_s^u (s)	→	→	→	→	☒	D_f^{36} (ice damage to rhizomes)		
AQUATIC 1	"	→	→	→	→	I_f^{36} (v)	☒	D_m^{36}	I_m^{36} (v)
AQUATIC 2	"	→	→	→	→	"	I_m^{36} (v)	☒	"
AQUATIC 3	V_{vs}^u(s)	→	→	→	→	D_m^{36}	"	D_m^{36}	☒

SPECIES: Phragmites communis- a phreatic species.

S_0 (INITIAL STATE)

S_t (FINAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND	X	NC			$E_f^{14.15}$	$E_f^{14,15}$	NC	NC	NC
UPLAND BANK	NC	X	NC	NC	"	"	NC	→	→
ICE PUSH	NC	NC	X	NC	"	"	NC	→	→
ICE SCOUR	NC	→	→	X	"	"	NC	→	→
PHREATIC	V_f^{32} (s)	→	→	→	X	I_m^{32} (v)	V_f^{32} (s)	→	→
EMERGENT	V_m^{32} (s) - requires less than 4 cm of water in summer for seedling establishment				NC (mature) Ef (seedlings)	X	$V_m^{14,15}$ (s+v)	→	→
AQUATIC 1	NC	NC	NC	NC	$E_s^{14,15}$(faster on fine sed's)		X	NC	NC
AQUATIC 2	NC	→	→	→	$E_f^{14,15}$	$E_f^{14,15}$	NC	X	NC
AQUATIC 3	NC	→	→	→	" →	→	" →	→	X

SPECIES: *Picea glauca*- dominant upland forest species on mesic sites 100 years ff. disturbance.

S_t (FINAL STATE)	S_0 (INITIAL STATE)								
	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND		$I_s^{26,27}$	$V_s^{26,27,28}$ (s)	→	→	→	→	→	→
UPLAND BANK	D_f^8 (mat.trees) $V_s^{27,28}$ (s)		"	→	→	→	→	→	→
ICE PUSH	"	→		NC	NC	$V_s^{26,27,28}$ (s)	→	→	→
ICE SCOUR	"	→	NC		NC	"	→	→	→
PHREATIC	D_f^1 (<4' trees) s (mat trees)	→	→	→		" (if soil surface exposed by July)			
EMERGENT	E_f^5	→	→	→	→		NC	→	→
AQUATIC 1	"	→	→	→	→	NC		NC	NC
AQUATIC 2	"	→	→	→	→	NC	NC		NC
AQUATIC 3	"	→	→	→	→	NC	→	→	

SPECIES: Pinus banksiana- an upland tree species on sandy soils and burned sites.

S_t (FINAL STATE) \ S_0 (INITIAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND		I_s^s	→	→	V_s^{27} (s) (on coarse soils that drain rapidly)			→	→
UPLAND BANK	D_s^s		NC	NC	"	→	→	→	→
ICE PUSH	NC (mat trees) D_f (< 4' trees)	→		NC	"	→	→	→	→
ICE SCOUR	"	→	NC		"	→	→	→	→
PHREATIC	E_m^1 (> 2 mo. flood)	→	→	→		NC	→	→	→
EMERGENT	E_f^1	→	→	→	→		NC	→	→
AQUATIC 1	"	→	→	→	→	NC		NC	NC
AQUATIC 2	"	→	→	→	→	NC	NC		NC
AQUATIC 3	"	→	→	→	→	NC	→	→	

SPECIES: *Picea mariana*- an upland species dominant with *Sphagnum* in ombrotrophic bogs where the w.t. is less than 50 cm., and on poorly drained uplands where it forms closed forests with *Hypnum*, esp. ff. light repeated fires.

S_0 (INITIAL STATE)

S_t (FINAL STATE)

	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND		$1-V_s^s$ (w.t.< 50 cm)	→	→	V_s^{26}	→	→	→	→
UPLAND BANK	D_f^8 (e)		V_s^s (s)	→	→	→	→	→	→
ICE PUSH	"	→		NC	V_s^{26}	→	→	→	→
ICE SCOUR	"	→	NC		"	→	→	→	→
PHREATIC	$E_s^{1,6,7}$ (>2 mo. flood)	→	→	→		V_s^{26} (dry ff. June)	→	→	→
EMERGENT	E_{f-m}^6 (r)	→	→	→	→		NC	→	→
AQUATIC 1	E_f^6 (r)	→	→	→	→	NC		NC	NC
AQUATIC 2	"	→	→	→	→	NC	NC		NC
AQUATIC 3	"	→	→	→	→	NC	→	→	

SPECIES: *Populus balsamifera*- a forest species common where the w.t. is within 1 m of the surface

S_0 (INITIAL STATE)

S_t (FINAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND		I_m^s (v)	→	→	V_s^{27} (s) (only where coarse sediments are exposed by drawdown).				
UPLAND BANK	D_s^s (e)		NC	NC	"	→	→	→	→
ICE PUSH	D_m^s (mat trees) V_m^{27} (s)	NC		NC	"	→	→	→	→
ICE SCOUR	"	→	NC		"	→	→	→	→
PHREATIC	D_m^8 (> 1 mo flood)	→	→	→		NC or V_s^{27} (s) (if dry following June only)	→	→	→
EMERGENT	E_m^u	→	→	→	→		NC	→	→
AQUATIC 1	E_f^u	→	→	→	→	NC		NC	NC
AQUATIC 2	"	→	→	→	→	NC	NC		NC
AQUATIC 3	"	→	→	→	→	NC	→	→	

SPECIES:Populus tremuloides- early successional upland forest species, esp. after moderately hot fires.

S_0 (INITIAL STATE)

S_t (FINAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND	☒	I^s_m	—	→	V^{27}_{f-m} (s)	—	—	—	→
UPLAND BANK	V^{27}_f (v+s)	☒	V^{27}_f (s) —	→	V^{27}_m (s)	—	—	—	→
ICE PUSH	" (s) —	→ (s)	☒	NC	"	—	—	—	→
ICE SCOUR	" —	→	NC	☒	"	—	—	—	→
PHREATIC	D^{35}_s (r)	—	—	→	☒	V^{27}_s (if dry ff. June)	—	—	→
EMERGENT	E^{35}_f (r)	—	—	—	→	☒	NC	—	→
AQUATIC 1	"	—	—	—	→	NC	☒	NC	NC
AQUATIC 2	"	—	—	—	→	NC	NC	☒	NC
AQUATIC 3	"	—	—	—	→	NC	—	→	☒

SPECIES: Potamogeton filiformis- a submerged species on fine sediments, up to 3 m depth.

S_t (FINAL STATE)	S_0 (INITIAL STATE)								
	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic
UPLAND	X	NC	→	→	→	E_f^{36}	→	→	→
UPLAND BANK	NC	X	NC	→	→	"	→	→	→
ICE PUSH	NC	NC	X	NC	NC	"	→	→	→
ICE SCOUR	NC	→	→	X	NC	"	→	→	→
PHREATIC	NC	→	→	→	X	"	→	→	→
EMERGENT	V_s^s (s)	→	→	→	→	X	D_f^{36} (winter ice damage and summer wave action)		
AQUATIC 1	$V_m^{s,45}$(s)	→	→	→	→	$I_f^{s,36}$	X	"	→
AQUATIC 2	"	→	→	→	→	"	$I_f^{s,36}$	X	D_s^s
AQUATIC 3	"	→	→	→	→	" $_{m-s}$	" $_{m-s}$	D_s^s	X

SPECIES: Potamogeton pectinatus- a submerged species common in shallow water up to 2 m; prolific seed producer.

S_0 (INITIAL STATE)

S_t (FINAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND	☒	NC	→	→	→	$E_f^{36,38}$	→	→	→
UPLAND BANK	NC	☒	NC	→	→	"	→	→	→
ICE PUSH	NC	NC	☒	NC →	→	"	→	→	→
ICE SCOUR	NC	→	→	☒	NC	"	→	→	→
PHREATIC	NC	→	→	→	☒	"	→	→	→
EMERGENT	$V_f^{37,39,41}$	→	→	→	→	☒	D_f^{36}	→	→
AQUATIC 1	"	→	→	→	→	I_f^{36}	☒	I_f^{36} →	→
AQUATIC 2	"	→	→	→	→	I_m^{36}	NC	☒	D_s^u
AQUATIC 3	"	→	→	→	→	NC	D_s^u	D_s^u	☒

SPECIES: Potamogeton praelongus- a submerged species characteristic of deep (greater than 3 m) water.

S_0 (INITIAL STATE)

S_t (FINAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND	X	NC	→	→	→	→	→	E_f^s	→
UPLAND BANK	NC	X	→	→	→	→	→	"	→
ICE PUSH	"	→	X	→	→	→	→	"	→
ICE SCOUR	"	→	→	X	→	→	→	"	→
PHREATIC	"	→	→	→	X	→	→	"	→
EMERGENT	"	→	→	→	→	X	→	"	→
AQUATIC 1	"	→	→	→	→	→	X	"	→
AQUATIC 2	V_s^s	→	→	→	→	→	→	X	D_s^s
AQUATIC 3	"	→	→	→	→	→	I_s^s →	→	X

SPECIES: Potamogeton richardsonii- a submerged species common over a wide range of depths and sediment types.

S_0 (INITIAL STATE)

S_t (FINAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND	X	NC	→	→	→	E_f^s	→	→	→
UPLAND BANK	NC	X	NC	→	→	"	→	→	→
ICE PUSH	NC	NC	X	NC →	→	"	→	→	→
ICE SCOUR	NC	→	→	X	NC	"	→	→	→
PHREATIC	NC	→	→	→	X	"	→	→	→
EMERGENT	NC	→	→	→	→	X	D_f^{36}	→	→
AQUATIC 1	V_s^s (s)	→	→	→	→	I_f^{36}	X	D_m^{36}	HC
AQUATIC 2	"	→	→	→	→	"	D_s^s	X	I_m^s
AQUATIC 3	"	→	→	→	→	HC	" →	→	X

SPECIES: Potamogeton vaginatus- a submerged species characteristic of coarse sediments and a wide range of depths.

S_0 (INITIAL STATE)

S_t (FINAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND	☒	NC	→	→	→	→	E_f^s	→	→
UPLAND BANK	NC	☒	NC	→	→	→	.	→	→
ICE PUSH	.	→	☒	NC	→	→	.	→	→
ICE SCOUR	.	→	→	☒	NC	→	.	→	→
PHREATIC	.	→	→	→	☒	NC	.	→	→
EMERGENT	.	→	→	→	→	☒	.	→	→
AQUATIC 1	V_s^s (s)	→	→	→	→	→	☒	D_m^s (ice and wave action;	
AQUATIC 2	.	→	→	→	→	→	I_m^s (v)	☒	NC
AQUATIC 3	.	→	→	→	→	→	.	NC	☒

SPECIES: Potamogeton zosteriformis- a submerged species characteristic of fine sediments,up to 2.5 m depth.

S_0 (INITIAL STATE)

S_t (FINAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND	X	NC	→	→	→	E_f^u	→	→	→
UPLAND BANK	NC	X	NC	→	→	"	→	→	→
ICE PUSH	"	→	X	NC →	→	"	→	→	→
ICE SCOUR	NC	→	→	X	NC	"	→	→	→
PHREATIC	"	→	→	→	X	"	→	→	→
EMERGENT	V_m^s (s)	→	→	→	→	X	D_f^{36} (ice damage to winter buds)		
AQUATIC 1	"	→	→	→	→	I_f^u (v)	X	"	"
AQUATIC 2	"	→	→	→	→	" →	→	X	D_s^s
AQUATIC 3	"	→	→	→	→	" →	→	D_s^s	X

SPECIES: Prunus pennsylvanicus- an upland species in mid-successional forest, especially after fire. A poor competitor.

S_0 (INITIAL STATE)

S_t (FINAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND	☒	D_s^{27}	→	→	V^{27}_{m-s} (s)	→	→	→	→
UPLAND BANK	I^{27}_m	☒	NC	NC	"	→	→	→	→
ICE PUSH	I^{27}_m	NC	☒	NC	V^{27}_{f-m} (s)	→	→	→	→
ICE SCOUR	"	"	NC	☒	"	→	→	→	→
PHREATIC	E^s_s	E^s_s	E^{27}_s	E^{27}_s	☒	NC	→	→	→
EMERGENT	E^s_f	→	→	→	NC	☒	NC	→	→
AQUATIC 1	"	→	→	→	NC	NC	☒	NC	NC
AQUATIC 2	"	→	→	→	NC	→	→	☒	NC
AQUATIC 3	"	→	→	→	NC	→	→		☒

SPECIES: Ribes spp. (hirtellum, hudsonianum, hirtellum, lacustre, oxyacanthoides)- an upland forest shrub in open sites.

S_0 (INITIAL STATE)

S_t (FINAL STATE)

	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND	X	D_s^s	→	→	V_s^7 (s)	→	→	→	→
UPLAND BANK	I_s^7	X	NC	NC	V_{m-s}^7 (s)	→	→	→	→
ICE PUSH	NC	NC	X	NC	V_{m-s}^7 (s)	→	→	→	→
ICE SCOUR	NC	→	→	X	"	→	→	→	→
PHREATIC	E_s^{26}	→	→	→	X	NC	→	→	→
EMERGENT	E_f^s	→	→	→	NC	X	NC	→	→
AQUATIC 1	E_f^s	→	→	→	NC	→	X	NC	NC
AQUATIC 2	"	→	→	→	NC	→	→	X	NC
AQUATIC 3	"	→	→	→	NC	→	→	→	X

SPECIES: Rosa aciculari*s*- an upland shrub species in early-mid successional forests.

S_0 (INITIAL STATE)

S_t (FINAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 4
UPLAND		NC	I_m^7 (s+v) →	→	V_m^7 (s)	→	→	→	→
UPLAND BANK	NC		• →	→	V_m^7 (s)	→	→	→	→
ICE PUSH	D_m^5	D_m^5		NC	•	→	→	→	→
ICE SCOUR	D_m^7	•	NC		•	→	→	→	→
PHREATIC	D_s^7	→	→	→		NC	→	→	→
EMERGENT	$E_f^{5,7}$	→	→	→	→		NC	→	→
AQUATIC 1	E_f^5	→	→	→	→	NC		NC	NC
AQUATIC 2	•	→	→	→	→	• →	→		NC
AQUATIC 3	•	→	→	→	→	• →	→	→	

SPECIES: *Rubus strigosus* (= *R. idaeus*)- an upland forest species.

S_0 (INITIAL STATE)

S_t (FINAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND	☒	NC	NC	NC	$V_{m-s}^{7,27}$, on fine inorganic sediments	→	→	→	→
UPLAND BANK	I_s^5	☒	NC	NC	$1, V_m^{7,27}$	$V_s^{7,27}$	→	→	→
ICE PUSH	I_s^{27}	NC	☒	NC	"	"	→	→	→
ICE SCOUR	D_m^7	NC	NC	☒	"	"	→	→	→
PHREATIC	E_s^7	→	→	→	☒	NC	→	→	→
EMERGENT	E_f^7	→	→	→	→	☒	NC	→	→
AQUATIC 1	"	→	→	→	→	NC	☒	NC	NC
AQUATIC 2	"	→	→	→	→	NC	NC	☒	NC
AQUATIC 3	"	→	→	→	→	NC	→	→	☒

SPECIES: Sagittaria cuneata- a heteromorphic species of shallow water and lake margin/phreatic habitats.

S_0 (INITIAL STATE)

S_t (FINAL STATE)

	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND	X	NC	—	→	E_f^u (d)	—	—	—	→
UPLAND BANK	NC	X	NC —	→	"	—	—	—	→
ICE PUSH	" —	→	X	NC	"	—	—	—	→
ICE SCOUR	"	—	→	X	"	—	—	—	→
PHREATIC	$V_m^{40,41,45}$ (s)	—	—	→	X	I_f^{41} (s)	—	—	→
EMERGENT	"	—	—	→	D_m^{41}	X	I_m^{41} (s)	—	→
AQUATIC 1	"	—	—	→	" —	→	X	I_m^{41} (s) —	→
AQUATIC 2	"	—	—	→	" —	—	→	X	I_m^5 (s)
AQUATIC 3	"	—	—	→	" —	—	—	→	X

SPECIES: Salix spp.- S. candida and S. petiolaris in bogs, S. discolor in woodlands.

S_t (FINAL STATE)	S_0 (INITIAL STATE) UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND	☒	NC	D_f^{27} I_s^{13} (discolor)	D_f^{27} I_s^{13} (discolor)	I_m^{13}	V_f^{13} (discolor)	→	→	→
UPLAND BANK	V_m^{27}	☒	NC	NC	"	"	→	→	→
ICE PUSH	"	NC	☒	NC	"	"	→	→	→
ICE SCOUR	"	"	NC	☒	I_m^{13}	"	→	→	→
PHREATIC	$D_m^{7,13}$	→	→	→	☒	V_s^s	→	→	→
EMERGENT	E_s^{13}	→	→	→	E_s^{13}	☒	HC	→	→
AQUATIC 1	E_m^{13}	→	→	→	→	→	☒	NC	NC
AQUATIC 2	E_f^{13}	→	→	→	→	→	NC	☒	NC
AQUATIC 3	"	→	→	→	→	→	NC	NC	☒

SPECIES: Scirpus validus- an emergent species that only tolerates permanent flooding on coarse sediments

S_0 (INITIAL STATE)

S_t (FINAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND	☒	NC	→	→	E^{13}_{m-s}	→	→	→	→
UPLAND BANK	NC	☒	NC →	→	"	→	→	→	→
ICE PUSH	" →	→	☒	NC	"	→	→	→	→
ICE SCOUR	"	→	→	☒	"	→	→	→	→
PHREATIC	$V^{13,45}_f$ (s)	→	→	→	☒	I^{13}_m	I^{13}_m or V^{45}_f	→	→
EMERGENT	NC (too wet for seeds to establish)		→	→	D^{13}_m E_m (fine sed)	☒	"	→	→
AQUATIC 1	"	→	→	→	E^{13}_m →	→	☒	NC	HC
AQUATIC 2	"	→	→	→	" →	→	NC	☒	HC
AQUATIC 3	"	→	→	→	" →	→	NC →	→	☒

SPECIES: Typha latifolia- an emergent species requiring less than about 10 cm of water for seeds to establish.

S_0 (INITIAL STATE)

S_t (FINAL STATE)	UPLAND	UPLAND BANK	ICE PUSH	ICE SCOUR	PHREATIC	EMERGENT	AQUATIC 1	AQUATIC 2	Aquatic 3
UPLAND	X	NC	—	→	E_s^u (d)	—	—	—	→
UPLAND BANK	NC	X	NC —	→	"	—	—	—	→
ICE PUSH	NC —	→	X	NC	"	—	—	—	→
ICE SCOUR	NC	—	→	X	"	—	—	—	→
PHREATIC	V_f^3 (surface must remain moist in July) —	—	—	→	X	I_s^{13} (v)	V_f^3	—	→
EMERGENT	$NC^{3,13}$ (too deep for seedlings to establish) —	—	—	—	→	X	NC	—	→
AQUATIC 1	"	—	—	→	E_{m-s}^{13} —	→	X	NC	NC
AQUATIC 2	"	—	—	→	E_f^{13} —	→	NC	X	NC
AQUATIC 3	"	—	—	→	" —	→	NC —	→	X

Appendix V

Terms of Reference and Project Proposals

Environmental Impact of Water Level Fluctuation on the Vegetation and Materials of Lakes near Cold Lake

A Proposal

Resource Evaluation and Planning Division
Alberta Energy and Natural Resources

Submitted by

Cameron McGregor
Resource Appraisal Section

June, 1981

INTRODUCTION

From discussions with you, it has become apparent that changes in the original project proposal (Appendix I) should be made. These revisions include:

1. Provision for the land component.
2. An investigation of the land-water interface.
3. An investigation of vegetation species and their response to flooding, or raising or lowering of the groundwater table.
4. A provision for an interdisciplinary evaluation including:
    i) recreation (boating, fishing, hunting, cottaging, beaches, etc.)
    ii) fisheries
    iii) wildlife
5. A provision for interaction with ongoing discipline-oriented studies.

These additional components require a substantial overhaul of the project and the time required.

STUDY DESIGN

This study will:

A. Inventory existing habitats (littoral, emergent, lake margin, phreatic, upland) in a .5 mile radius around selected lakes.

B. Extrapolate the habitat information to other lakes of importance in the lake management program. These extrapolations will be tested in the field and a confidence interval for each habitat determined for the lakes as a whole.

C. Predict the effects of flooding or the raising and lowering of the groundwater table on these habitats. This will be based upon the autecology of dominant species and important species for wildlife and fisheries, as well as important recreational considerations such as lands for campsites, beaches, etc.

D. Interface with other studies in the program to provide an integrated approach.

In addition, the lakes for water management will be grouped into an ecological framework, compatible with the Ecological Land Classification of Cold Lake (Ojamaa 1976).

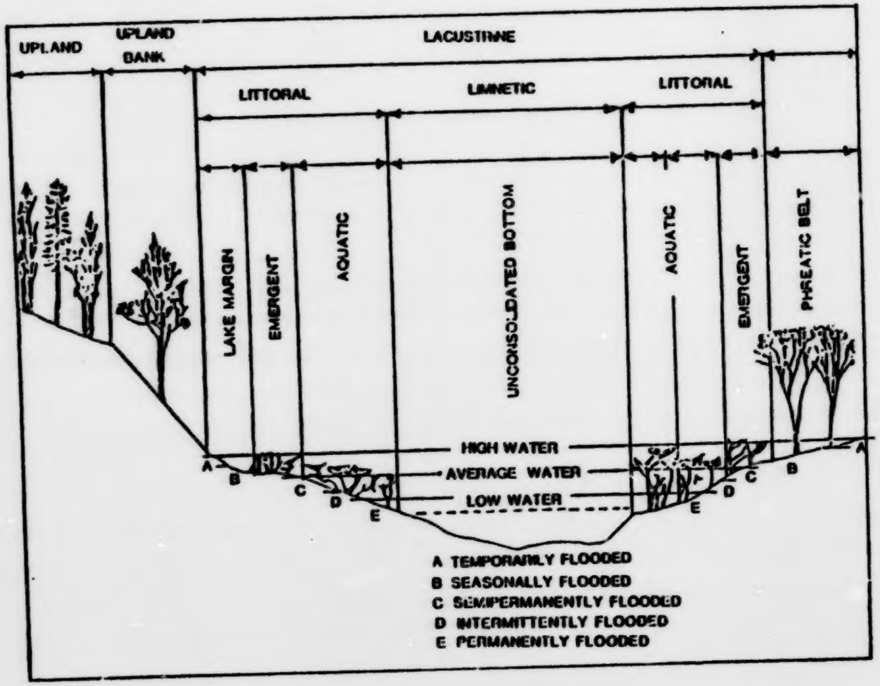
Part A: Inventory of Existing Habitats

The inventory of existing habitats will rely heavily on existing information abcut the area, which is extensive. Habitats will be separated into Upland, Phreatic, Lake Margin, Emergent, and Aquatic.

Descriptions of upland and phreatic habitats will include:

i) surficial materials (including slope, texture, local relief, genesis, aspect)

ii) soils (classified to soil series or great group dependent upon literature sources)


UPLAND
UPLAND BANK
LACUSTRINE
LITTORAL
LIMNETIC
LITTORAL
LAKE MARGIN
EMERGENT
AQUATIC
UNCONSOLIDATED BOTTOM
AQUATIC
EMERGENT
PHREATIC BELT
HIGH WATER
AVERAGE WATER
LOW WATER
A
B
C
D
E
A TEMPORARILY FLOODED
B SEASONALLY FLOODED
C SEMIPERMANENTLY FLOODED
D INTERMITTENTLY FLOODED
E PERMANENTLY FLOODED

iii) vegetation (stratified into tree, tall shrub (1 m - 5 m), medium shrub (3 dm - 1 m), dwarf shrub (3 m), tall herbs and grasses (3 dm - 1 m), low herbs and grasses, arboreal lichens and terricolous lichens and mosses. Abundance will be measured by % cover.

Descriptions of lake margin, emergent and aquatic habitats will include:

i) surficial materials (including texture, slope, genesis, local relief, aspect)

ii) water depth and clarify (where appropriate)

iii) vegetation (stratified into height classes including 1 - 3 m, 0.3 - 1 m, 0 - 0.3 m). Abundance will be measured by % cover.

Profiles of representative land-water interfaces will be developed for each of the lakes selected for intensive study.

These habitats will be mapped at a scale of 1:31 680 using photos flown on July 15, 1969. Where appropriate, other imagery will be used to determine lake levels at flood and maximum drawdown. The interpreted photographs will be submitted upon completion of the project.

The mapped information will be transferred to 1:50 000 N.T.S. sheets and submitted in the final report.

Part B: Extrapolation of Habitat Inventory to Other Lakes

The detailed habitat inventory of selected lakes will be extrapolated to other lakes by:

i) air photo interpretation
ii) investigation of NTS 1:50 000 topographic sheets and bathymetric maps (provided by Alberta Environment)

The extrapolation will be field tested for an appropriate number of lakes to determine a confidence interval for each habitat type and the ecological niche of dominant or important vegetation species (literature will also be relied upon to establish each niche). This testing will serve as a reliability estimate of each habitat.

Part C: Production of the Impact of Water Level Fluctuation

Literature will be relied upon to assess the response of important species to flooding or raising and lowering of the groundwater table. Proposed species are given in Appendix III. In addition, test data from Part B will be utilized to provide a more area-specific estimate.

Species will be ranked as:

i) eliminated
ii) invaders
iii) increasers
iv) decreasers

according to moisture regimes and changes in habitat. Classes are given in Appendix II.

In addition, surficial materials important to recreation such as potential dock sites, beaches, potential campsites will also be evaluated according to the same moisture regimes.

Part D: Interface with Other Studies

In Figure 2, an interaction model is proposed. This study evaluates the effect of changing moisture regimes on the plants and materials of the lakes, effectively the primary productivity. These predictions will be of use to Fisheries, Wildlife, and Recreation, so that they may evaluate changes to their own resources.

It is anticipated that this interaction will be achieved by one meeting prior to fieldwork to "fine tune" the study design and two to three meetings post fieldwork to bring your consultants up-to-date with the program

			Effect on sedonary productivity: a) fish b) aquatic mammals c) big game
Industrial requirements for water and land	Modelling of water level fluctuations	Expected changes surficial materials and primary productivity	Effect on man: hunting, fishing, recreation areas, boating, etc.

Figure 1.1

MANPOWER

The following time requirements will be necessary to complete the project:

	Man Days
Literature Review	
1. Communities, soils, surficial geology	5
2. Water relationships of dominant and important plant species	15
Air Photo Interpretation	
13 lakes at one day per lake	15
Fieldwork	
5 lakes; detailed survey, 3 days per lake	15
8 lakes; habitat extrapolation, 1 day per lake	10
Data Analysis	
Detailed	5
Extrapolation	5
Report Preparation	20

	Man Days
Project Management	10
Project Coordination	5 ?
Client Liaison	5 ?
Total	115

SPECIAL EQUIPMENT AND SERVICES

1 - boat, motor and trailer

1 - stovepipe to view weeds

1 - snorkle, diver's mask, flippers and weight belt

1 - plumb with a 25' cord graded into 1 foot intervals

1 - secchi disc

5 days - 2 hours per day - helicopter with floats

An estimate that between 40 and 50 days of drafting may be required:

13 lakes at 1:50 000 - 2 days per lake	26 days
20 transect figures - 1 day per figure	20 days
Total:	46 days

Can you provide this service?

TIMING

To be determined.

TERMS OF REFERENCE

PROJECT DESCRIPTION: LAKE RESOURCE APPRAISAL - BEAVER RIVER BASIN

Purpose

To describe the littoral zones of lakes in the study area.

Methods

1. Lakes will be grouped into land regions and districts according to the Sand River Soil Survey, the Cold Lake Ecological Land Classification and air photo evaluation.

   Representative lakes from each ecodistrict will be surveyed in detail to determine:

   (a) correlations of littoral zone and texture and macrophyte growth with shoreline materials and vegetation

   (b) correlations of littoral zone texture and macrophyte growth with prevailing winds, storm winds, up-river type, etc.

2. The detailed lake studies will be used to predict the aquatic macrophyte distribution and texture of other lakes within the land district. This prediction will be tested on other lakes in each district to determine the inherent variability of lakes in the district.

3. A literature survey will be integrated to determine:

   (a) those physical attributes of lakes which are responsible for changes in weed growth

(b) expected primary and secondary successional changes in weed growth

4. Correlation of habitat description with the prediction of fish abundance (lead to be taken by Fish and Wildlife).

Work required will include:

1. Air photo interpretation - 1:40 000
   1:10 000 - 1:15 000

2. Literature review

3. Fieldwork

4. Data analysis

5. Report preparation

Classes

Surficial Geology (from Kocaoglu, S.S. 1975. Reconnaissance Soil Survey of the Sand River Area (73L). Alberta Institute of Pedology, Report No. S-74-34).

Genesis	Slope	Texture
Hummocky Morainal Plain (I)	6-30	Clayey to sandy (see Figure A1)
Rolling Morainal Plain (IV)	2-15	Fine loamy to sandy (see Figure A2)
Undulating Morainal Plain (VI)	.5-5	Fine loamy (see Figure A3)

Soils (from Kocaoglu, 1975).

There are approximately 17 soil series in the study area. These are summarized in Figures A1-A3.

Vegetation (from Ojamaa, P., 1978). Biophysical Analysis and Evaluation of Capability Cold Lake Area, ENR Report No. 59; Nordstrom, W.R., 1976. A Resource Assessment and Development Capability of the Cold Lake Study Area, Resource Assessment and Management Section, Alberta Recreation and Parks; Hydrogeological Consultants Ltd. 1974. Touchwood Report; Alberta Municipal Affairs, 1979. Muriel Lake Management Study, Regional Planning Section.

Upland:

- Coniferous Forest
  - Jack pine dominated
  - White spruce dominated
- Mixedwood
  - Jack pine dominated
  - White spruce dominated
  - Aspen dominated
- Deciduous
  - Aspen dominated
  - Birch dominated
- Phreatic
  - Black spruce dominated muskeg
  - Larch dominated muskeg
  - Brushland
- Lake Margin
  - Grassland
- Emergent
  - Cattail dominated
  - Bulrush dominated
- Aquatic
  - Chara dominated
  - Patamogeton delineated

__Moisture Regime__:

1. Flooded: 6'
   4'
   2'

2. Groundwater raised: 4'
   2'

3. Groundwater lowered: 4'
   2'

__Textural Classes__:

Lakes

Sandy
Organic
Silty
Stoney

Land - follows CSSC, 1978. The Canadian System of Soil Classification, Canadian Department of Agriculture, Publication 1646.

__Slopes__:

Lakes:

Less than 5%
5-20%
More than 20%

Land - follows CSSC, 1978

DOMINANT SPECIES TO BE INVESTIGATED FOR THEIR WATER RELATIONSHIP (TENTATIVE)

Trees

Pinus banksiana
Picea glauca
Picea mariana
Abies balsamea
Populus balsamifera
Populus tremuloides

Shrubs

Salix spp.
Alnus crispa
Alnus tenuifolia
Betula occidentalis
Betula pumila
Actea rubra
Ribes spp.
Amelancher alnifolia
Rosa acicularis
Prunus pensylvanica
Prunus virginiana
Ledum groenlandicum
Vaccinium myrtilloides

Aquatics

Potamogeton filiformis
Potamogeton pectinatus
Potamogeton richardsonii
Potamogeton vaginatus
Potamogeton zosteriformis
Elodea canadensis
Sagittaria cuneata
Chara spp.
Uticularia vulgaris
Nuphar variegatum

Emergents

Caltha palustris
Typha latifolia
Sagittaria cuneata

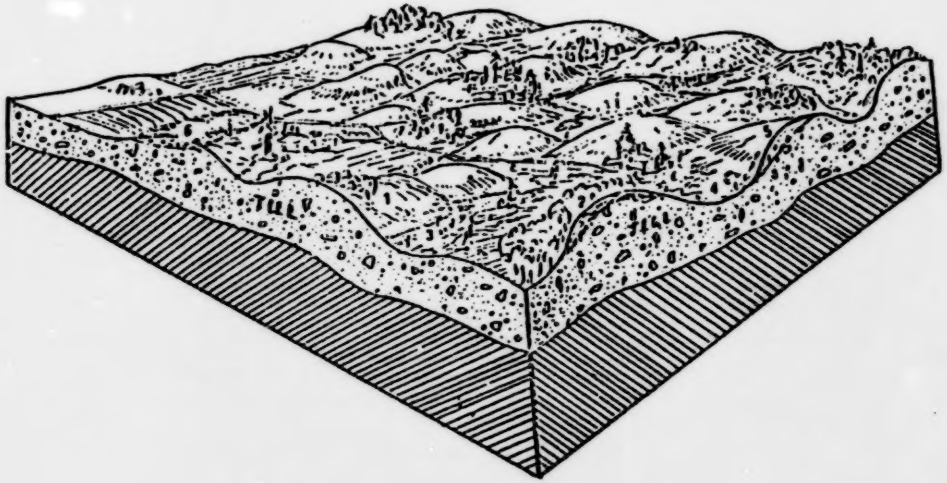


Figure 11. Block-diagram of land unit I—hummocky morainal plain, indicating landscape position of representative soils (see Table 7)[1]

Table 7. Common soils of the hummocky morainal plain (Figure 11) and their landscape relationships

	Map unit component	*Soil group*	*Parent material*	*Drainage class*	*Landscape position*
1	Athabasca	Orthic Gray Luvisol	Fine-loamy, weakly calcareous glacial till	Moderately well drained	Upper and midslope
2	Grandin	Orthic Gray Luvisol	Fine-clayey, weakly calcareous glacial till	Moderately well drained	Upper slopes and ridge tops
3	Organic		Sphagnum or forest peat	Poorly to very poorly drained	Low-lying depressions
4	Newbrook	Low Humic Eluviated Gleysol	Fine-loamy, weakly calcareous glacial till	Poorly drained	Receiving areas on lower slopes
5	Codesa	Degraded Eutric Brunisol, Orthic Gray Luvisol	Sandy alluvium over fine-loamy glacial till	Well drained	Upper slopes
6	Edwand	Degraded Eutric Brunisol	Sandy-skeletal, glacio-fluvial material	Rapidly drained	Ridge tops

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[1] from Kocaoglu 1977

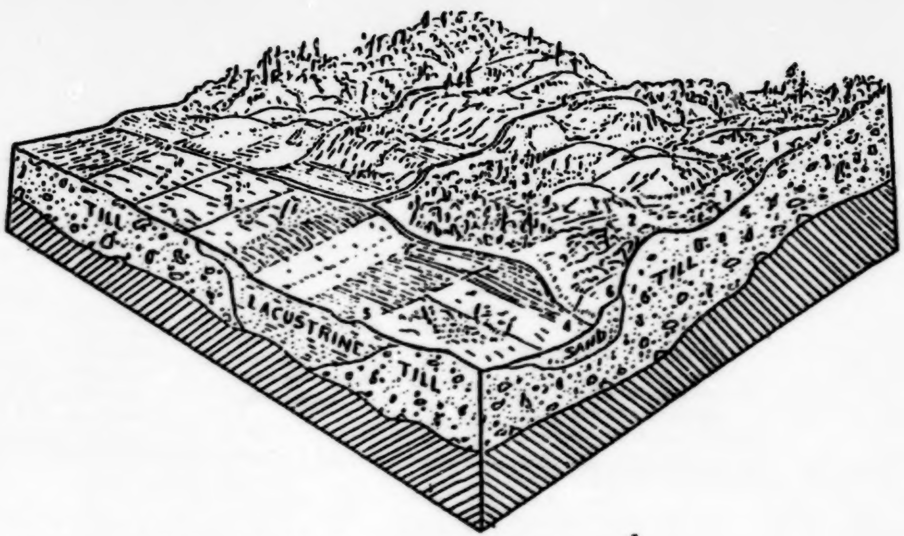

Figure 12. Block diagram sketch of land unit IV—rolling morainal plain, indicating landscape position of representative soils (see Table 10)[1]

Table 10. Common soils of the rolling morainal plain (Figure 17) and their landscape relationships

	Map unit component	*Soil group*	*Parent material*	*Drainage class*	*Landscape position*
1	Tomson	Orthic Gray Luvisol	Fine-loamy, moderately to strongly calcareous glacial till	Moderately well drained	Upper and midslopes
2	La Corey	Orthic Gray Luvisol	Fine-loamy, moderately to strongly calcareous glacial till	Moderately well drained	Upper and midslopes
3	Organic		Forest or fen peat	Poorly to very poorly drained	Low-lying depressions and drainageways
4	Neslow	Degraded Dystric Brunisol	Sandy alluvial or aeolian material	Rapidly drained	Midslopes
5	Tolman	Orthic Gray Luvisol	Fine-loamy, moderately to strongly calcareous lacustrine material	Well drained	Mid and upper slopes
6	Codesa	Degraded Eutric Brunisol, Orthic Gray Luvisol	Sandy alluvium over fine-loamy glacial till	Well drained	Mid and upper slopes
7	Newbrook	Low Humic Eluviated Gleysol	Fine-loamy, weakly calcareous glacial till	Poorly drained	Receiving areas on lower slopes

[1] from Kocaoglu 1977

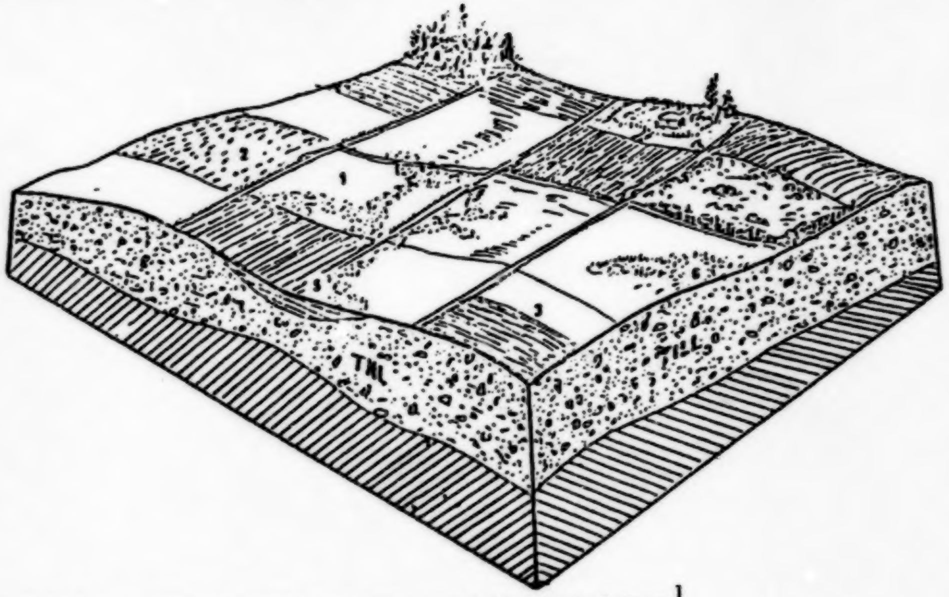

Figure 43. Block-diagram sketch of land unit VI—undulating morainal plain, indicating landscape position of representative soils (see Table 12)[1]

Table 12. Common soils of the undulating morainal plain (Figure 21) and their landscape relationships

	Map unit component	*Soil group*	*Parent material*	*Drainage class*	*Landscape position*
1	Fergy	Eluviated Black Chernozemic	Fine-loamy, moderately to strongly calcareous glacial till	Well drained	Nearly level lower slopes
2	Kehiwin	Orthic Dark Gray Chernozemic	Fine-loamy, moderately to strongly calcareous glacial till	Well drained	Long midslopes
3	Spedden	Dark Gray Luvisol	Fine-loamy, moderately to strongly calcareous glacial till	Moderately well drained	Midslope
4	La Corey	Orthic Gray Luvisol	Fine-loamy, moderately to strongly calcareous glacial till	Moderately well drained	Upper slopes
5	Ponoka	Eluviated Black Chernozemic	Fine-silty, moderately to strongly calcareous lacustrine material	Well drained	Nearly level lower slopes
6	Mapova	Humic Eluviated Gleysol	Fine-loamy, weakly calcareous glacial till	Poorly drained	Lower slopes in a more receiving position

[1] from Kocaoglu 1977

POOR

QUALITY

ORIGINAL